DOCUMENT RESUME

ED 137 073 SE 022 004

AUTHOR Babski, Carl A.
TITLE Developing and Testing a Pilot Module Program for Physical Science.
PUB DATE 76
NOTE 125p.; Ed.D. Practicum, Nova University; Contains occasional light type

EDRS PRICE MF-$0.83 HC-$6.01 Plus Postage.
DESCRIPTORS *Achievement; *Attitudes; *College Science; Community Colleges; Educational Research; Higher Education; *Instruction; *Physical Sciences; *Science Courses; Science Education; Science Units

ABSTRACT

Evaluated were undergraduate college students in a basic physical science course. Students were instructed by a modular approach and a conventional lecture and discussion approach. No significant differences were found in content achievement or attitudes. (RH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED137073

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

Developing and Testing a Pilot Module Program for Physical Science

Carl A. Babski

A MAJOR APPLIED RESEARCH PROJECT PRESENTED
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF EDUCATION

NOVA UNIVERSITY

1976

SE 022 004

ACKNOWLEDGEMENTS

Special gratitude is extended to my major advisor and chairman, Dr. J. Don Boney, a truly professional educator whose support, patience, understanding, guidance, and encouragement augmented by successfully completing this worthwhile doctoral project.

Appreciation is also expressed to each member of the committee - Dr. George Barton, Dr. John Losak, Dr. James Chinn. Their cooperative attitude and practical suggestions proved to be highly beneficial. Of course, this study could not have occurred without the one hundred percent sincere participation of the selected faculty and students at Miami-Dade Community College, North Campus.

Appreciation is extended to many loyal friends for their advice and concern: to Carl Stocker and James Lamar, professional colleagues and personal friends whose advice and meaningful feedback were indispensable; to John Scerba and Fred Smith, dedicated educators for their invaluable assistance in statistical analysis; to Mathematics/Physics Chairperson, Bradley Lawrence and assistant George Rumsey.

Special appreciation goes to Jane Morganroth, typist, proof reader and sounding board.

Abstract of a Major Applied Research
Project Presented to Nova University in Partial
Fulfillment of the Requirements for the Degree
of Doctor of Education

DEVELOPING AND TESTING A PILOT MODULE PROGRAM FOR PHYSICAL SCIENCE

The purpose of this study was to re-evaluate and re-define the course content of Physical Science 101; to realign the course by creating modules. Specifically, this study was planned to measure the achievement gain and attitude change of physical science students at Miami-Dade Community College (North) in a modular approach as opposed to the traditional lecture-discussion method. Four modules were utilized in the study.

The evaluation was a multi-faceted approach -- one that emphasized both the cognitive and affective changes that occur in the student as a result of the experimental modular curriculum. The independent variables for the study were method of instruction and instructors. Each of the instructors of the course had a control group and an experimental group. The dependent variables were achievement test scores and course grade average. The affective variables were attitude scale score, course evaluation, and teacher evaluation. The cognitive variables, achievement and course grade average, were analyzed by the computer available at Miami-Dade Community College. The program called MANOVA was used to

analyze the data in a two-by-two factorial design, i.e., two instructors and two methods with the pre-achievement test being the covariate. The post-achievement test also was analyzed with the covariate program, but the GPA was the covariate. The pre-post attitude method determined the attitude change. An analysis of covariance was computed with the pre-attitude as the covariate. The course evaluation and teacher evaluation were analyzed by an analysis of variance program. All the covariance programs satisfied the requisite assumptions for both linear regression and analysis of variance homogeneity. The variance of the different groups were all homogeneous to enable the use of the analysis of variance computer programs.

Results of the analysis to compare the effectiveness of teaching by a learning modular approach as compared to teaching by the traditional lecture-discussion method indicated that the experimental group did perform more effectively than the control group, but not at a significant level. The analysis of covariance determined the instructional modular method to be no more effective than the traditional method when testing with pre-post achievement method and controlled to the pre-achievement. The instructional modular method was significant at the .05 level when the post-achievement was controlled to the GPA in an analysis of covariance. Analysis indicated some teachers probably are more effective in a modular approach.

From the analysis of the data, no significant differences were found in the course grade average of the instructional methods. However, the instructional module system did out perform the control groups as concluded from the means but not at a significant level.

There was no significant difference in the course evaluation by the instructional method. However, a significant change in attitude by the experimental group was revealed from the analysis. Specifically, there was also no significant difference in the teacher evaluation by the instructional groups.

The physical science course at Miami-Dade Community College (North) needs more study before the modular system is available to all physical science students. The program is being continued and the statistical analysis is being made. The situation developing has produced a unique challenge in that it has brought into sharp focus the general education problem prevalent throughout the country. It is not unreasonable to hope that any progress made here might be quite relevant to colleges across the country.

TABLE OF CONTENTS

PAGE

ACKNOWLEDGEMENTS ii
ABSTRACT iii
LIST OF TABLES viii
LIST OF FIGURES . . . . ~~vii~~ x

CHAPTER

I. INTRODUCTION 1
    Background and Statement of Problem 1
    Purpose and Modular Objectives 5
    Major Issues 7
    Summary 11
II. REVIEW OF LITERATURE AND RESEARCH 12
    Design of Modules 12
    Content of Modules 21
    Summary 26
III. PROCEDURE AND METHODOLOGY 27
    Hypothesis 27
    Assumptions 28
    Limitations 28
    Population 28
    Surveys 28

PAGE

Developing Modules 31

Course Structure 32

Analysis of Results 32

IV. RESULTS 36

Hypothesis Results 36

Summary 45

V. IMPLICATIONS AND SIGNIFICANCE 46

Brief History 46

Present and Future Status 46

BIBLIOGRAPHY 49

APPENDIXES 57

LIST OF TABLES

PAGE

TABLES

1. Means and Standard Deviation for Pre-Achievement, Post-Achievement, and Grade Point Average With Two Factors, Teachers and Methods 37

2. An Analysis of Covariance For Achievement Differences Between Two Instructional Methods with Two Teachers Controlled for Pre-Achievement 37

3. An Analysis of Covariance For Achievement Differences Between Two Instructional Methods with Two Teachers Controlled for Grade Point Average 38

4. A Multiple Analysis of Covariance of Experimental and Control Methods for Achievement Performance With Two Teachers. Covariates: Grade Point Average and Pre-Achievement 39

5. Means and Standard Deviation for Course Grade Average With Two Factors, Teacher and Method 40

6. An Analysis of Covariance For Course Grade Average Difference Between Two Instructional Methods With Two Teachers Controlled For The Grade Point Average 41

7. Means and Standard Deviations For Pre-Attitude and Post-Attitude With Two Factors, Teacher and Method. 42

8. An Analysis of Covariance For Post-Attitude Differences Between Two Instructional Methods With Two Teachers Controlled For Pre-Attitude Test. 42

9. Means and Standard Deviations For Course Evaluation With Two Factors, Teacher and Method. 43

10. An Analysis of Variance For Course Evaluation Differences Between Two Instructional Methods With Two Teachers 44

11. Means and Standard Deviation For Teacher Evaluation With Two Factors, Teachers and Instructional Method. 44

12. Analysis of Variance For Teacher Evaluation With Two Factors, Teacher and Instructional Method 45

LIST OF FIGURES

FIGURE PAGE

1 An Instructional Design 16

CHAPTER 1

INTRODUCTION

Background and Statement of Problem

Among the goals of the Division of Arts and Sciences at Miami-Dade Community College, North, are those expressly aimed at meeting student need by providing knowledge for their cultural advancement. This goal is achieved primarily by the offering of the general education courses. The objectives of these courses are usually relevant to modern living and contemporary society. The division objectives include the development of instructional methodologies which take into account the individual differences of student learning capabilities with emphasis on the attainment of instructional objectives. It is readily apparent today that these goals are not being achieved. This is attested to by lack of interest of students, a ten to fifteen percent drop-out rate, and to some extent, a certain frustration which students feel in the general education courses.

Local Trends. A minor rationale for this study is generated by the records of the enrollment in general education courses in the Arts and Sciences Division at the Miami-Dade Community College. The total general education enrollment for the Arts and Sciences Division from 1968 to 1974 has declined from ten thousand students to less than six thousand in 1974. In particular, the physical science department enrollment has declined from a high of three thousand in 1968 to less than five hundred in 1974.

The department enrollment indicates that physics has suffered a major general education decrease since 1969. Faculty and administrative searches for valid reasons are nearly futile. Faculty usually give three reasons for the decline.

1. National military draft ceased.
2. Students wish more relevance in courses or just fear the name of the course "Physics."
3. The growing number of general education classes in other departments and the College Level Examination Program.

National Trends. Society today needs more science education, or, as sometimes termed, more general science knowledge. The extent of the needs depends upon the goals and interests of each individual. Some individuals want to make natural phenomena more understandable while others have a desire to make what is known about natural phenomena more useful to man. At the same time, all individuals of our society have a need for a better understanding of basic scientific concepts and activities, not to make them better scientists, but to help them become more knowledgeable citizens.

Hurd (1970) feels that general education programs - including science - must prepare future adults to expect change and to meet change without shock, fear, or anxieties. To help attain this result, he recommends that general science give the student the opportunity to (1) look through the door of science (2) see the growth of scientific ideas (3) be exposed to knowledge about scientific activities; and (4) study the various interrelationships of science and other social activities. In other words, science education should provide each individual with an understanding of science that will help him make intelligent social and political decisions.

"Scientific literacy" in the late 1950's and throughout the 1960's was the phrase coined to express this quest for effective citizenship via science education. Prominent national educators, as well as science teachers' associations have expressed their support of this concept. In 1964, the Curriculum Committee of the National Science Teachers Association (NSTA) stated: "Science teaching must result in scientifically literate citizens" (NSTA, 1964).

In 1971, NSTA's Committee on Curriculum Studies re-affirmed this scientific literacy idea as follows: "The major goal of science is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action, (CCS, 1971).

Many scientists and science educators agree with Gatewood when he states:

> In a society that is as scientifically and technologically oriented as ours is today, all students should be broadly educated in science, in its processes, its products, its philosophy, and its impact on society...The single most important goal of school science must be to prepare scientifically literate citizens for the future, (Gatewood, 1968).

Hurd, who prefers the phrase "scientific enlightenment" to further emphasize "scientific literacy", advocates resolute and conscientious curriculum reform. He states:

> What is needed now is a curriculum designed to bring about an understanding of the scientific and technological enterprises and the ramifications of social integration of both...the broader perspective of scientific enlightenment embedded in a social context, we have the potential of moving school science courses from their present isolation into the "real world" of the student, (Hurd, 1970).

Scientific Literacy. Everyone uses the term "scientific literacy". There is, therefore, a need for a more specific definition or description of the concept to be established so that better communication is possible. A frame of reference will help establish and consolidate the many definitions. This will answer the question "Who is scientifically literate?" The references are as follows:

> 1. A scientifically literate person knows something of the role of science in society and appreciates the cultural conditions under which science survives, and knows the conceptual inventions and investigative procedures. A scientifically literate person understands the interrelationships of science and society (NSTA, 1964).
>
> 2. ...an educated man should know science in a humanistic way... he should feel comfortable when reading or talking with others about science on a nontechnical level, (Shamos, 1963).
>
> 3. A scientifically literate person will be curious about the how and why of materials and events -- will be genuinely interested in hearing and reading about things that claim the time and attention of scientists, (Pella, 1969).

A more specific description that includes various attributes has been formulated by Hurd and Gallagher in their study of Social Aspects of Science. Their emphasis is on growth rather than on a finished product; they visualize an individual using his formal science education as a foundation for further growth.

According to Hurd and Gallagher, the scientifically literate person will increasingly:

A. Appreciate the sociohistorical development of science.

B. Become aware of the ethos of modern science.

C. Understand and appreciate the social and cultural relationships of science.

D. Recognize the social responsibility of science.

Instruction for Scientific Literacy. The paramount question is "How should the teaching of science be organized to foster the development of scientifically literate citizens?" Rabinowitch answers:

> (Science Education) should provide further generations not only a general understanding of science as such but most of all capacity to appreciate those aspects of science which affect the future of man, the impact of science on public affairs, on the fate of our own nation, and mankind as a whole. This means that science should not be taught as a separate body of technical facts or an autonomous system of ideas but in relation to other disciplines that traditionally mold the attitude of growing generations toward society and the world they will live in, history, political science, sociology, etc., (Rabinowitch, 1958).

In support of this point of view, Hurd maintains:

> A general education in the sciences should make it possible for people to appreciate the worthiness of the scientific enterprise and to use its achievements. This means that the present science curriculum will need to be changed to provide a wider picture of science...(Hurd, 1970).

This statement indicates a great need for restructuring the teaching of science, including the removal of the barriers between the various natural sciences and between the natural sciences, social sciences and between the humanities.

Purpose and Modular Objectives

Purpose. While the guidelines asserted by Hurd, Shamos and others, are of structural significance, Miami-Dade Community College is also guided by the needs of its students which are to be met in the physical science curriculum. This project was designed to re-evaluate, and re-define course content of Physical Science 101; to realign the course into modules with objectives according to projected life in the 80's and to improve the instructional strategies in order to prepare the student to meet Future Shock (Toffler, 1972) with less fear.

Modular Objectives. In particular, this project developed modules for these basic reasons:

(1) Improved instructional strategies in order to reduce attrition. This is another way of saying that the modules developed should be liked by the students and the general fear of physical science should be reduced.

(2) To improve instructional methodologies, basically involving modules which, in this brief encounter with science, would develop two objectives: (1) help the individuals to recognize their need for better understanding of science and technology and (2) motivating them to satisfy their needs for better understanding.

While each module was developed so that students could master selected stated objectives for that module, the overall modular program was directed towards the successful accomplishment of the following objectives:

1. To present relevant science concepts for today's living.

2. To provide the student some opportunity to participate in the selection of topics to be studied.
3. To provide learning opportunities for students who have wide variations in their preparation and present capabilities.
4. To provide a variety of instructional strategies and methodologies which consider the differences in the rate of student learning.
5. Student performance was evaluated on the degree of attainment of modular objectives.
6. An evaluation system of the modules was instigated to delete and create modules on a continuous basis.

Major Issues:

Search for Methodology in Modules. How can a workable program be developed so that all students can achieve meaningful goals for their lives in a democracy? This was the challenge. Meiller (1973) states that, "the science course must be open-ended. That the course must stress the inquiry process of science. Inquiry should provide the learner with tools for independent learning." Inquiry is a broad range of activities performed to explore and search out variables and attributes relevant to discrepant stimuli (Wilson, 1974).

Inquiry can result whenever or wherever stimuli challenge the existing expectations of participants. This situation can occur in a well equipped laboratory, or it can occur in a well planned and produced lecture, a stimulating reading assignment, or just a simple novel situation in which students feel they have some control (Hermann, 1969).

Keller (1974) and DeWitt (1972) have shown that the laboratory is an excellent approach for activities of inquiry into phenomena. Wilson (1973) found that stressing inquiry affects the science attitude with average and below average students. Thus, the modules were so created to include activities in the laboratory or the student has the option to attend the demonstration-discussion section which was on the phenomena to be studied. The student thus had some choice in selecting the learning model which helped him to learn.

The demonstration-discussions section each week emphasized the National Science Foundation basic concept of the last few years. The Foundation has shifted teaching emphasis from repeatable knowledge (what students can say afterwards) as a primary focus in the classroom to a focus on what the students are doing cognitively (the mental operation involved) and how students feel about it (their attitude toward science). The Foundation's theme is that inquiry develops positive attitudes. In "Innocence in Education" Bloom re-emphasized this idea, "Modern education increasingly stresses attitude and values and new views of man in relation to his society and to himself."

Diedrich (1972) felt that textbooks treat science as a series of conclusions rather than an outcome of inquiry. He felt that teaching science in the context of the development opens up vast areas of discussion for the classroom. This idea was encouraged to be used by the instructors in the discussion sections.

New Patterns. New patterns were needed in order to approach a goal of scientific literacy. Familiar patterns proceed in a stepwise fashion from the defined problem in a Dewey-like decision-making model to a formulation of a conclusion. These patters are summarized from Wilson (1974).

1. The student is placed in the role of scientist.
2. A second better approach places the learner in situations where inquiry into new phenomena or explanations is performed with external guidance. In this approach, guidance provides direction necessary to yield a profitable experience and produce desired concept attainment (Hermann, 1969).
3. A third, and preferred approach, focuses on inquiry as a collection of subsets of skills. Inquiry in one lesson may be quantification tactics with data provided. Still another lesson may explore observation of curious events. The emphasis here is upon acequisition not only of the content, but also of the specific process relative to a heuristic of inquiry.

Guidance, hints, or guidelines as referred to above in parts 2 and 3 provide lesson sequences that explain phenomena by providing activities that familiarize the learner with the phenomena, make available related phenomena and facts, and guided the conceptual experimentation. The patterns developed in the modules were mostly on the approaches summarized in (2) and (3) above. The new pattern development was in the criteria selection of curriculum relevance to be presented below.

Summary of Guidelines for Modules. The modules provided the learner with teaching model options that were to satisfy him and provide inquiry that produce challenge. The teacher's model options were lecture, discussion-demonstration, built-in individualized instruction and new strategies and methodologies. Yet, with these same tools the slow learner was favored with the wide variety of activities and guidance.

Three areas of guidance directed our development of modules.

1. Criteria for Student/Curriculum Relevance.
2. Methodology
3. Strategies

1. Criteria for Student/Curriculum Relevance

   A. Scientific Literacy -- Provide a basic scientific background which anyone might find helpful in increasing his effectiveness both as an individual and as a member of his community.

   B. Personal Needs -- Focus on those areas of science which contribute directly to the fulfillment of some of the personal needs of the students, as opposed to the more diffuse relevance implied in scientific literacy. A short course in nutrition, or chemistry of cosmetics were intended to have this kind of relevance. This entailed developing individualized instruction as part of the modules.

   C. Professional Needs in Areas Other Than Science -- Help the student in his professional development in the field of his major (which is other than science). For example, a module on light might contain a submodule on photographic optics for media majors.

   D. Community Responsibilities -- The idea here was to deal with environment and other survival problems for the maintenance of the Third Planet.

2. Methodology

The analysis and evaluation of subject matter was guided by the experts contacted, literature reviewed and on the topics of interest survey of the student population at Miami-Dade Community College. This guidance can be reviewed in the literature section, Chapter 2 and survey results.

3. Strategies

At present the strategy was a lecture on Monday and Tuesday. This was followed with a discussion section on Friday with an option to do an experiment on the same phenomena. Other strategies involve varying the length of the module for variable credit, relevant topics, and productive use of professional visitors on topics.

Summary

With these criteria for student/curriculum relevance, methodologies, and stated objectives the project was developed to answer two questions: (1) Can the module-oriented physical science course produce a higher achievement than the lecture method, and (2) Can the module-oriented physical science course produce a more positive attitude toward science when compared with a non-modularized science course?

CHAPTER II

REVIEW OF LITERATURE AND RESEARCH

Introduction

This project was designed to re-evaluate and re-define the course content of Physical Science 101 and to re-align the course by creating modules to produce a higher achiever and a better attitude toward science. This chapter reviews the research and literature which contributed guidelines to the design and content of these modules.

DESIGN OF MODULES

Brief History

A pioneer in the programmed teaching movement in the 1950's was B. F. Skinner, Harvard Professor of Psychology. This development gave birth to the teaching principles which invoked the characteristic of both programmed instruction and the broader individualized instruction approach, (Skinner, 1957). This instructional system provided: subject matter in small steps, active student involvement, immediate confirmation of student progress, positive reinforcement, student self-pacing, and revision of instruction material for the desired level of achievement by the learner, (Roueche, 1970). This system has been modified or developed in numerous forms by numerous authors. Influencing these developments was the behavioral objective system in the late fifties and early sixties. Three contributors in the three areas of taxonomy of objectives were: Bloom (1956), Krathwohl (1964), and Simpson (1966). These authors analyzed objectives in three areas: cognitive, affective, and psychomotor domain. However, colleges throughout the country in their staff development classes mostly utilized Mager's books (1962,1968) as did Miami-Dade Community College in their orientation to behavioral objectives and the writing of course outlines.

Program Development. From this research development of Skinner and others discussed, Keller (1968) developed an individualized system of instruction. Green (1971), Koen and Keller, (1971), and Dressler (1971) described the basic elements of the Keller Plan:

1. Mastery was the criterion for advancement.
2. The course was divided into small units.
3. The student was provided with specific objectives and means to obtain these objectives.
4. The course was non-competetive regarding grade.
5. The method provided for continuous feedback. Students knew where they stood.
6. Students could get personal help from their tutor.
7. Students were not afraid of tests. No penalty for not passing.

Program Outcome. Many colleges across the country have developed or are developing the self-instructional packages, (Corey, 1970; Dressler, 1971). However, indications are that the programs are now declining and as a result educators are analyzing the reasons for its decline (Friedman, 1976). Educators are beginning to salvage certain elements of individualized instruction. This project and creating these modules are a part of that salvaging. Miami-Dade Community College taught Personalized System of Instruction (PSI) in all of its physics courses for two years (1972-73) including physical sciences. That program has been abandoned (1974). However, PSI is available for selected individuals. These modules contain the successful attributes of PSI as objectives and learning guidance to improve the learning situation.

Literature Review

Curriculum Guide. There was a time when the assessment of the success of a new science course, curriculum, or program was quite a casual affair. Some impressive test scores, a few testimonials from teachers and other experts, plus a collection of posed photographs showing seriously involved students were all that was needed to assure anyone who cared to ask that an innovation in science instruction was working well. But times have changed, and science educators are now accepting the responsibility for conducting much more careful evaluations of innovations in science teaching. Not only are new courses and programs being evaluated in terms of various criteria, but evaluation also plays an important role in the very process of developing any new science curriculum.

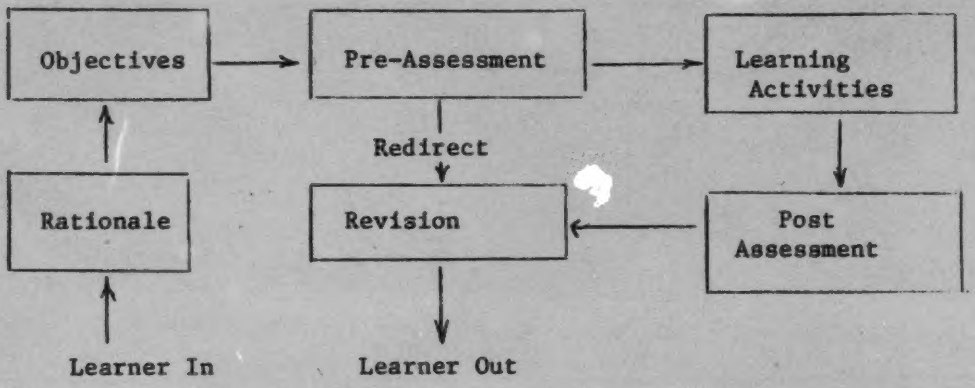
For the purpose of curriculum development, Champagne and Kloper (1974) provided an extensive check list of over two hundred questions to be answered when contemplating curriculum development. The essential headings for questions to be asked are:

1. Conceptionalization and Planning
    - A. Rationale, Goals, and Objectives
    - B. Plans for Developing the Curriculum
2. Student Instructional Material
    - A. General Considerations
    - B. Printed Instructional Materials
    - C. Manipulative and Scientific Apparatus
    - D. Non-Print Media
3. Student Behavior with Respect to the Science Content
4. Student Behavior in the Classroom Environment
5. The Teacher

Courses Attempted. Short courses were attempted in many colleges but not all courses followed a modularized format. However, these mini-courses or modular packages were part of the evolution of the modularized system which featured elements utilized in self-instruction of Keller (1968) and others. Boston College in 1973 started mini-courses for non-science majors devoted to single topics of interest of students and faculty, (Uritam, 1973). The setting in which these courses emerged was the ongoing revolution in science education which Uritam (1972) felt had not been stressed. The mini-courses provided many topics for diversity to meet the interest of the students. Soxman (1972) at Mississippi State College also introduced mini-courses of isolated topics of interest. This article provided a list of ideas for modular development. Beers (1973) was also convinced that short courses could make possible equality of education because they provide solutions to difficult problems such as relevancy and flexibility which allowed students to select topics of interest. Calendra (1972) reported excellent results with mini-courses at Washington University in St. Louis. "The use of tours and visitors of professional status augmented interest," stated Calendra. Collagen (1970) used modules to instruct non-technical and non-science personnel at Goddard Space Flight Center.

Modular Design. With the development of mini-courses, Personalized System of Instruction (PSI) and behavioral objective system, it was inevitable that the three systems were united. The student enrollment in physical science across the nation at this point in development was down; and educators were attempting to find the ultimate system for attracting students and providing them with a better learning system. Slapar (1974) organized modular physics but still utilized a separate book of references. The des[illegible] of the module was similar to individualized instruction, but there were lectures. Herrscher (1971) provided the following schematic, Figure 1, which was similar to Johnson (1970).

Figure 1. An Instructional Design



Steps in Accepted Format of Modules. The modular format designed was similar to the American Instiute of Physics (1975) design.

(1) Prerequisites: These statements specify the required entering behavior for the module.

(2) Rationale: The student should be informed why it is important that he master the material.

(3) A Pre-Assessment Test based on (a) the prerequisites and (b) the objectives of the unit. A student lacking prerequisites would be referred first to developmental or remedial materials. One who already had the desired abilities (specified by the objectives) would go on to the next module.

(4) A Learning Activity: This activity was a laboratory activity, reading provided in the module, or augmented with additional references. The teacher lectured and provided stimuli. All materials were presented through multi-media, such as films or film loops, audio tapes, video tapes or printed material. (About 90% of reading material needed for the unit was in the module.)

(5) An Exit Test based on the objectives provided the student a feedback for evaluation.

(6) Revision: A re-cycling occurred if the student failed, but this time an individual study plan or the Teaching Center was utilized. The Teaching Center provided free tutoring service.

Research Review

Non-Science Majors Studies. Olsen (1972) concluded at the University of Maryland that the use of behavioral objectives in a physical science class can enhance the performance on achievement test and retention. The investigation was with the Interaction of Matter and Energy published by Rand McNally and Company for the Ninth grade level.

An auto-tutorial genetics course was designed for non-science majors to increase scientific literacy. The science major's perception of scientific literacy did not differ significantly from non-science major's perceptions of scientific literacy. In addition, non-science majors who enrolled in the course changed significantly in their perception of scientific literacy on three of the six concepts tested, (Gross, 1971). This may indicate that auto-tutorial may be useful in the design or learning activity of a module.

In a project using history of science case studies approach, the experimental group indicated significantly higher results. The test utilized in this study was the Test of the Aspects of Scientific Thinking. The group consisted of eleven science case studies, any one of which could be developed into a modular format, (Hall, 1972). However, Barter (1968) in a physical science course by case history approach discovered this design to be neither more nor less effective than the subject matter centered approach in promoting achievement in scientific facts, concepts, and principles. This complete study was to compare three methods of teaching physical science:

(1) a subject matter centered approach

(2) an approach which emphasized the historical development of

science and its social and cultural interrelationships, and (3) a historical approach with a laboratory. There was no significant difference in the achievement on science subject matter knowledge among any of the groups.

An idea for one module design was suggested by the research of Young (1969). This design for a physical science course was to determine whether or not students could learn as effectively in a team learning approach as they could in a standard lecture approach. Retention effect was in favor of the control group.

A study in Psychology of the Exceptional Child Course was designed to use module approach as compared to teaching using the traditional method. The data indicated students were able to gain as much achievement in the modular class as they were to gain in the traditional method. Students subjectively indicated they preferred the learning module approach to learning. No indication was given as to the format of the module, (Dale, 1973).

Laboratory Search. Should a laboratory be included? This was the question that developed early in the curriculum design, and, of course, what kind and how much laboratory time should be used in the design. Stekel (1970) and Smith (1971) both did very similar studies. Stekel compared open-ended experiments with student involvement in problems and experimental design to the traditional laboratory manual method. Smith compared the physical science course with a laboratory as Stekel did, but labeled the difference: vicarious experimentation versus conventional experimentation. Smith concluded that the vicarious method helped the student develop student ability to think critically and to promote achievement in the understanding of science subject matter content. Stekel was not as favorable in Smith's areas but did agree student planning the laboratory had significant results in one area. That area was in understanding the process of science which included: observation, measurement, and experimentation.

Allen (1975) likewise concluded that the preference of students for activities that included abstract ideas or had concrete ends was not changed by the degree of freedom they had in directing their own laboratory work. The preference of students for activities that can be dealt with in an orderly systematic manner or that allow the student to express ideas through laboratory write-ups was not changed by the degree of freedom in directing their own laboratory work. Also, there was no change in the students' understanding of the process of science when the degree of freedom in laboratory direction was varied. Whitten's (1971) results indicated that the laboratory does make important contributions to the results on the Test on Understanding Science, Form W, (TOUS).

Other ideas of design centered around auto-tutorial, workbook type experiments, or just discussion periods in the laboratory. Simpson (1969) designed a study to compare the effectiveness of three types of laboratory: (1) traditional, where the student was asked to do a workbook-type of experiment, (2) the student was given a choice of doing a prepared experiment or designing his own, and (3) no laboratory;time devoted to reading and discussion. The three treatment groups were not found to be significantly different in any respect at the end of the semester. The conclusion was that the laboratory was not found to aid in achieveing general education objectives, and the treatments were judged to be equally effective.

With respect to auto-tutorial laboratory being included in some modules, Rowbotham (1969) found that the auto-tutorial favored the average and low ability group. However, Rowbotham did not find the auto-tutorial laboratory to be more effective than the traditional laboratory, it was found to be as effective.

CONTENT OF MODULES

Brief History. Since Sputnik, the development of science programs, in particular physical science, has exploded into many directions. The development started with Physical Science Study Committee in the mid-fifties and grew rapidly. Physical Science for Non-Science Majors was developed in 1963 through 1965 by a joint committee composed of the Commission of College Physics and the Advisory Council on College Chemistry, (PSNS, 1969). This course had experiments and reading materials combined in one book with a philosophy to develop a feeling for science through the process approach.

Others as Introductory Physical Science (I.P.S., 1969) developed an overwhelming supply of experiments and subject matter ideas. All of these courses provided a selection of materials and experiments which some proved very effective. The selection of what to include in a module was a judgement problem, but these project courses provided an adequate source of experiments and ideas.

Research Review. Student unrest in the sixties and the development of a possible counterculture supposedly antagonistic toward the objective nature of science has led in recent years to the development of various courses aimed at communicating with the non-science major. These were courses other than those developed from physics projects discussed in the brief history. Spears (1975) discovered that both science majors and non-science majors supported science with the same magnitude of interest. The non-science majors do have an attitude considered necessary for the growth of science. However, the non-science majors were unsure as to whether or not science contributed to the values of life. From the Schwirian Science Support Scale used in the survey, certain theme ideas for course development or modules were suggested:

1. What effect has science and its resulting technology had upon people and their well being?
2. What was the relationship between science and religion in dealing with man's world and man's behavior?
3. What was the role of science in society as one of encouraging critical thought and the acceptance of different ideas? This role carefully excluded references to religion and morality.

The National Council on Physics in Education in cooperation with the New Jersey Science Teachers Association surveyed nine colleges and fourteen high schools (seniors only) to identify the sure fire ingredients of a course for non-science majors. The answers from 1,300 students were quite clear:

1. The course should include as much hands-on experimental work as possible.
2. In the laboratory there must be a "relaxed atmosphere" and freedom to move around and discuss results with one's fellow students.
3. The teacher must be well-grounded in the subject, genuinely interested in it, and honestly sympathetic with the problems that the non-science student has in dealing with the science course, (Wood, 1973).

Literature Review. The new pattern development for the modules was centered around the criteria selection of curriculum relevancy. Four areas of guidance or divisions were to help develop the modules. The four areas of the criteria for student-curriculum relevancy were: (1) scientific literacy, (2) personal needs, (3) professional needs in areas other than science, and (4) community responsibilities (See Chapter 1, p 10). The four areas will be discussed below under separate headings.

1. Scientific Literacy

Beams (1974) believed that scientific literacy can be enhanced by problem-center approach on current issues as people pollution, and solar energy. The science principles were developed in the course as the problem was investigated; and heavy emphasis was placed upon resource people. The course was interdisciplinary. Anderson (1974) and Calendra (1972) both agreed with current issue themes and insisted that they must be short courses so that students can pick the topics they wished to study. These short courses could be modules if developed into the proper format.

Romer (1973) preferred the approach to scientific literacy through scientific theory study and how they developed. Browner (1975) suggested the same development and both have developed courses that were good evidence that the method was successful. A module could be developed centered on just one theory.

2. Personal Needs

The literature revealed that many new courses developed were returning to the philosophical and religious approach to meet personal needs. Transylvania University of Kentucky had topics in short modules or mini-courses investigating scientists and their relationships to humanities. (Roeder, 1972). McGuire's (1972) idea for a new course was also the cultural approach. McGuire emphasized physics as a human activity with the view that it is neither as incomprehensible nor as removed from the general cultural as was commonly thought. Subjects included science and technology, science and religion, and physics and ecology. Each topic could be developed into the modular format. Vinson (1975) should also be included under personal needs topic because his new course included topics of this nature in addition to professional needs which follows in the next section. Calendra (1972) created technological short courses on nutrition, cosmetics, and exercise which were well received by students. Calandra was located at Washington University in St. Louis.

3. Professional Needs

Vinson (1975) new course as mentioned previously included a list of interdisciplinary topics. The list included drugs and chemistry, freedom and social control, education in a technological world of the future, and others which gave excellent guidance topics for modules to be developed.

To inject relevancy into their course at California State University at Long Beach and to attract school teachers, art students, and others, the faculty attempted to place emphasis on a more creative focus. Their topics as light and art; light, lasers, and color, and applied optics, attracted a large following, (George, 1974).

Rossing (1971) provided excellent laboratory ideas and topics for musicians at St. Olaf College, Minnesota at Northfield. Lowry (1975) has physical education mini-courses with some modular format at the University of Texas. Lowry's topics included physics of sports.

4. Community Responsibilities

Three authors who provided outstanding topics were Cothern (1973), Uritam (1972), and Cowan (1972). Cothern's course utilized journals, magazines, and newspapers to provide attitude change for students from fear and hostility toward science to an understanding and appreciation. Testing for attitude change has proved this course effective. Materials that were used in the course were listed in the article. Cothern provided excellent resource material; Uritam and Cowan were also good resource articles for modular or mini-course outlines. Hewitt (1972) proved to be another article of lesser value for modular topic construction.

Summary

The research and literature review has been accomplished under two headings: (1) Design of the Module, and (2) Content of the Module. Under the first heading the three educational developments of behavioral objectives, personalized instruction, and mini-courses each partially contributed to a final modular design. Under content of module, a search for the best interest and relevancy topics was conducted. This search has contributed to an ongoing development of modules.

CHAPTER III

PROCEDURE AND METHODOLOGY

The purpose of this study was to compare the effectiveness of teaching by a learning module approach as compared to teaching using a traditional lecture discussion method. Especially, the study planned to measure the achievement gain and attitude change of physical science students at Miami-Dade Community College. This chapter describes the procedures used in conducting and evaluating that project. It includes the following areas of activities: (1) Hypotheses (2) Assumptions (3) Limitations (4) Population (5) Surveys (6) Developing Modules (7) Methodology of the Course (8) Analysis of Results.

Hypotheses

1. When the results of the achievement of the experimental and control groups are compared, no significant differences will be found.

2. When the results of the course grade average of the experimental and control groups are compared, no significant differences will be found.

3. When the results of the post-attitude test used with the experimental and control groups are compared, no significant differences will be found.

4. When the results of the course evaluation of the experimental and control groups are compared, no significant differences will be found.

5. When the results of the teacher evaluation of the experimental and control groups are compared, no significant differences will be found.

Assumptions

1. The sample was assumed to be reasonably homogenous and representative of the Miami-Dade student population taking physical science.

2. The instructors were assumed to be unbiased in their attitude toward either method of instruction.

3. The assumption was made that all testing was not being affected by the "halo effect."

Limitations

1. The pilot program was restricted to testing four modules.

2. The time elapse of fifteen weeks is a very short time to cause behavior change in science attitude.

3. The course evaluation was affected at the end by the students' general feeling of "tired of filling out forms."

Population

The sample consisted of106 students enrolled in physical science at Miami-Dade Community College, North Campus. The beginning sample was 160 students, but that number decreased due to 15 withdrawals and 39 incomplete test results. The population was enrolled in two control classes and two experimental classes. The control group was the larger group with a total of 60 students. The experimental group contained 46 students.

Surveys

Two surveys were conducted to ascertain the topic development and two surveys provided feedback for formulative evaluation. These four survey areas were: (1) experienced personnel (2) student topics interest survey (3) student modular evaluation survey (4) teacher modular evaluation survey. Discussion on these surveys is presented in the following paragraphs.

Experienced Personnel. Numerous personnel interested in the module system development were contacted to assist in the design of the modules. A list of the highest contributors to the modules design from the physics community is in Appendix A . A national Physics Modular Consortium (PHYMOD) has been formed and was funded by federal money. The PHYMOD group was interested in modular development at the graduate level. The Physics of Technology modular design as presented in Chapter II, page 16 was the design found most acceptable. The Physics of Technology was another national modular study committee in the vocational area.

Student Topic Survey. Interested faculty members were asked to submit a list of topics of short teaching duration last year, 1975. This list appears in Appendix B . The title and department suggesting the title is indicated in the chart. This list was distributed to approximately 400 students and they were required to pick twelve topics which they would like to study. Student suggestions for topics also were encouraged. The survey results are presented in Appendix C . Topics appeared to favor what most students would label "high relevancy."

Student Modular Evaluation Survey. The student form of the evaluation survey (Appendix D)provided feedback for opinions and thus possible revision. Students were picked at random by the computer for the survey distribution. At least ten surveys were completed on each module with the Astronomy Module having a high of twenty-five. A mean was computed for the eleven questions. Appendix E has these results. Question seven is the only question whose results should be a high number. The mean should tend to the lower number on all other questions for good results.

A four member faculty committee's evaluation for all modules results was satisfactory. However, comments written by students on the measurement module indicated that some revision needs to be completed to reduce the feeling of difficulty. Although a few dissonant comment notes were sounded by students, the general rating scale results were satisfactory.

Faculty Modular Evaluation Survey. No tabulated data were obtained from this survey. However, a number of questions were of high interest. Questions 2 through 4 covered topics which were concerned with math at the right level, proper time for work required, and interestingly written. In general, the evaluators' comments were satisfactory, but suggestions for spot revisions were received and were made. This survey form was completed by the two instructors and utilized as a guide by the four member faculty reading committee. The reading committee included a former member of the National Science Committee for Two Year College Physics, Science Reviewer for Prentice Hall, and Division Directors of two different community colleges. All members hold a doctorate degree in either physics, chemistry, or science education. Four department reviewers were also utilized. A copy of the module evaluation survey form is in Appendix F.

Developing Modules

Four modules were developed for testing in this pilot program. The titles of the modules were Astronomy, A Longer Yard, Automobile Collision, and Heat and Energy . The four modules are in a separate booklet. A brief subject caption follows.

Astronomy - This module provided a study of the principles dealing with the earth's motions and motions of objects in the sky. Topics included: eclipses, planets retrograde motion, earth's annual motions, etc.

A Longer Yard - This module presented an introduction to the metric system of measurement.

Automobile Collision - The study of objects in motion employed the following terms: speed, velocity, acceleration and inertia. These essential topics and others were incorporated into the study of the automobile as it moves and as it is involved in collisions.

Energy and Heat - To understand heat and energy was the objective of this module. Topics included: conservation of energy, types of energy, units of measurement, use in consumer's market, and effect of energy and heat as related to human well-being.

A four member faculty committee was formed to assist in reading and evaluating the modules. The four modules created were thought of as the basic scientific literacy core in physics.

Course Structure

Four sections of Physical Science were used to collect the necessary data on the modules and lecture sections. Two teachers were utilized. Each teacher had a lecture section and a module section.

Control Section. These sections were taught by the lecture-discussion method. The control sections had no laboratory and no guest speakers. The control sections, however, did have the identical course objective list as the experimental group. The control sections used Exploring the Physical Sciences by William Poppy.

Experimental Sections. Here the students received the modules which attempted to more effectively meet their needs. The modules contained reading material, references, laboratory activities, questions, discussion-demonstration, objectives, and multi-media to attempt to match the student learning pattern. The module was a facilitator to learning, augmented by the teacher and learning resource center (library). Each module included a tour and a visitor of a professional status. A sample module is in Appendix G.

Analysis of Results

The evaluation was constructed to measure the cognitive and affective changes that occur in the student as a result of the curriculum.

Independent Variables. Two independent variables were considered.

1. Method of Instruction Two instructional methodologies were studied. The control section was the traditional lecture discussion section. A modular approach was utilized with the experimental group. Each method had basically the same objectives and covered the same material. However, the experimental sections differed from the control section by having the modular package, laboratory, and professional guests.

2. Instructors Two instructors conducted the instruction. Each instructor had an experimental and a control section.

Dependent Variables. Cognitive and affective changes were evaluated in this project. A total of five variables were considered.

Cognitive Variables:

1. Achievement Test Scores The forty-four question achievement test was administered at the beginning of the semester to both experimental and control groups, and as a post-test at the conclusion of the four modules. The test was developed at Pennsylvania State University. The test was shortened and analyses produced a Cronbach's Coefficient Alpha on the internal reliability of 0.8. (Appendix H).

2. Course Grade Average The averages were determined by averaging the tests on the four module examinations. The same objective tests were given to the control and experimental sections. All tests contained the same number of questions.

Affective Variables:

3. Attitude Scale Scores This thirty question test was administered to the experimental and control groups at the beginning and conclusion of the modules. The final test (post-test) was taken as an indication of final attitude toward the course. There were two sections in this test. One section investigated the student's attitude toward the laboratory, fifteen sematic differential questions did this. The other fifteen questions were concerned with the intellectual and emotional scientific attitudes of the students. A copy is in Appendix I . Both sections of the test had negative responses and the responses had to be adjusted to give a positive score. The test was developed by Welch (1973) and portions by Osgood (1957) and Snider (1969). The authors proved the reliability for each section.

4. Course Evaluation This is a standard course evaluation test developed and used at Pennsylvania State University. It has a reliability of 0.9. This test has been used in previous semesters at Miami-Dade and the Testing Center at North Campus found the interval reliability with a Cronbach's Alpha Coefficient of 0.9. A copy of the test is in Appendix J . The test was administered at the conclusion of the four modules.

5. Teacher Evaluation This twenty-four question test was developed

at Miami-Dade Community College and used for teacher's evaluation. The Cronbach's Alpha Coefficient is 0.9. A copy of the test is in Appendix K . The test was administered at the conclusion of the modules.

Method of Analysis. The cognitive variables achievement and final grade were analyzed by a program distributed by Clyde Computing Service, Box 166, Coconut Grove, Florida, called MANOVA, Multiple Analysis of Variance. The program analyzed the data in a two-by-two factorial design, i.e., two instructors and two methods, with different covariates. The two-by-two design utilized two covariates, pre-achievement and grade point average, in the first analysis against the post-achievement test. An analysis on the post-achievement was programmed on separate covariates, pre-achievement and grade point average. The attitude post-test also utilized this program, but the covariate was the attitude pre-test. The course evaluation and teacher evaluation used an analysis of variance program.

CHAPTER IV

RESULTS

Specifically this study was planned to measure the achievement gain and attitude change of physical science students in a modular approach as opposed to the traditional lecture-discussion method. This chapter presents the results of the evaluation of the experimental curriculum.

Hypotheses Results

Hypothesis 1. (When the results of the achievement of the experimental and control groups are compared, no significant differences will be found.) In Table 1 are the adjusted means, the standard deviations and grade point averages used in the analyses of covariance. The requisite assumptions for analysis of covariance for both linear regression and analysis of variance was satisfied. The F value (3.318) representing the difference between the instructional methods was not significant. However, inspecting the adjusted means from pre-to-post provided some insight. The adjusted means for the experimental group between pre-to-post when compared to the control group showed that the modular students performed better than the students taught by tradtional methods, as shown in Table 1. (See next page.)

The teachers' influence for the results was significant at the .05 level with an F value of 4.366 shown in Table 2. (Comparing the two post-achievement means of the two teacher's experimental group, a t-test was significant at the .05 level. The t value was 7.53 with 44 degrees of freedom. Only One teacher had a significant influence. Finally, the interaction of teachers and methods was not significant with an F/1.346 as indicated in Table 2. The hypothesis was acceptable.

Table 1. Means and Standard Deviations for Pre-Achievement, Post-Achievement, and Grade Point Average with Two Factors, Teachers and Methods.

FACTORS			VARIABLES			
TEACHERS	METHODS	STUDENTS	MEAN STANDARD DEVIATION	PRE-ACH (adjusted)	POST-ACH (adjusted)	GPA
1	Experimental	22	M	45.818	52.636	2.715
			SD	9.565	17.657	0.613
1	Control	39	M	41.872	48.718	2.596
			SD	10.388	10.420	0.713
2	Experimental	24	M	44.792	59.000	3.015
			SD	12.251	14.322	0.543
2	Control	21	M	43.333	51.048	2.966
			SD	13.120	8.919	0.689

Table 2. An Analysis of Covariance For Achievement Differences Between Two Instructional Methods With Two Teachers Controlled for Pre-Achievement.

SOURCE OF VARIATIONS	SUM OF SQUARES	DEGREES OF FREEDOM	MEANS OF SQUARES	F
Within Cells	13358.855	101	132.266	
Teachers	577.504	1	577.504	4.366 *
Methods	438.879	1	438.879	3.318
Teachers & Method	178.051	1	178.051	1.346

Further investigation was conducted with the post-achievement test. An analysis of covariance was computed using the covariate GPA. Table 3 reveals no significance for variation between teachers and no significant difference attributed to the interaction of teachers and methods. However, the instructional methods when adjusted to the GPA covariate was significant at the .05 level producing an F value of 4.434. The average of the means for the post-achievement modular method was 55.818 as compared to the average of the means of the control groups of 45.933. The average for the means for the two experimental groups and the two control groups were computed. These results make apparent the differences between the two instructional methods.

Table 3. An Analysis of Covariance For Achievement Differences Between Two Instructional Methods With Two Teachers, Controlled for Grade Point Average.

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEANS OF SQUARES	F
Within Cells	15954.352	101	157.964	
Teachers	285.344	1	285.344	1.806
Methods	700.480	1	700.480	4.434 *
Teachers & Method	119.473	1	119.473	0.756

The last analysis of the assumption on the first hypothesis utilized a multiple analysis of covariance using grade point average and pre-achievement as the covariates.

Table 4. A Multiple Analysis of Covariance of Experimental and Control Methods for Achievement Performance With Two Teachers, Covariates: Grade Point Average and Pre-Achievement:

SOURCE OF VARIATIONS	SUM OF SQUARES	DEGREES OF FREEDOM	MEANS OF SQUARE	F
Within Cells	13255.461	101	132.555	
Teachers	416.656	1	416.656	3.143
Methods	429.602	1	429.602	3.241
Teacher & Method	179.891	1	179.891	1.357

The performance of the modular group again had a better achievement when comparing means, however it did not reach significant level. An F value between methods of 3.241 was very close to being significant (Table 4). The F value for methods is also greater than the F value of teachers, 3.143, but neither was significant. The F for the interaction was not significant, indicating no appreciable relationship between performance on the test and the combinations of the two independent variables.

Summary. The first hypothesis was acceptable from the analysis results for pre-to-post achievement test. However, judging the GPA to be the more acceptable standard for the covariate, the first hypothesis was untenable. Some researchers, such as Popham (1967) and Winer (1962) suggest that findings of achievement performance is more reliable using the grade point average as the covariate. As previously shown, the teacher influence was not significant when controlling to the grade point average, but significant in pre-to-post achievement results.

Hypothesis 2. (When the results of the course grade average of the experimental and control groups are compared, no significant differences will be found.) The means and standard deviation are shown in Table 5.

Table 5. Means and Standard Deviation for Course Grade Average With Two Factors, Teacher and Method. ~~Two Levels for Each Factor.~~

FACTORS				VARIABLES	
TEACHERS	METHODS	STUDENTS	MEAN STANDARD DEVIATION	COURSE AVERAGE	GPA
1	Experimental	22	M	29.500	2.715
			SD	6.069	0.613
1	Control	39	M	28.333	2.596
			SD	5.732	0.713
2	Experimental	24	M	28.292	3.015
			SD	6.286	0.543
2	Control	21	M	27.810	2.966
			SD	6.282	0.689

An analysis of covariance was computed on the course grade average with the GPA as the covariate. The requisite assumptions for analysis of covariance for both linear regression and analysis of variance was satisfied. The F ($p < .001$) of 45.427 was significant for the linear regression.

TP → In testing this hypothesis, the F($p < .05$) value of 0.165 in Table 6 for instructional methods was not significant. However, the teachers proved to be significant with an F of 5.964. The relationship between the two independent variables, teachers and methods, and dependent variable, course grade average, results was not at a level of significant difference.

Inspection of the means proved again that the experimental group did have a higher mean result, but not at a level of significant difference. The hypothesis was acceptable.

Table 6. An Analysis of Covariance For Course Grade Average Difference Between Two Instructional Methods With Two Teachers Controlled For The Grade Point Average.

SOURCE OF VARIATIONS	SUM OF SQUARE	DEGREES OF FREEDOM	MEAN S OF SQUARE	F
Within Cells	2566.174	101	25.408	
Teachers	151.532	1	151.532	5.964*
Methods	4.193	1	4.193	0.165
Teachers and Methods	0.634	1	0.634	0.025

Hypotheses 3. (When the results of the post-attitude test used with the experimental and control groups are compared, no significant differences will be found.) The means and standard deviation are provided in Table 7. An analysis of covariance was computed on the post-attitude test with the pre-attitude as the covariate. In testing the requisite assumptions for analysis, the linear regression was satisfied. The variance of the groups was relatively homogeneous.

Table 7. Means and Standard Deviations For Pre-Attitude and Post-Attitude With Two Factors, Teacher and Method.

FACTORS			VARIABLES		
TEACHERS	METHOD	STUDENTS	MEAN STANDARD DEVIATION	PRE-ATTITUDE	POST-ATTITUDE
1	Experimental	22	M	85.909	97.545
			SD	13.487	17.582
1	Control	39	M	89.077	88.026
			SD	12.351	12.468
2	Experimental	24	M	86.958	95.042
			SD	10.507	13.183
2	Control	21	M	93.905	94.333
			SD	7.784	6.988

The analysis results are indicated in Table 8. This hypothesis was not accepted in one area. The attitude difference in the instructional groups had an F value ($p < .05$) of 5.229 which is highly significant. The teacher's influence was non-significant as well as the interaction of the independent variables. The hypothesis was not accepted.

Table 8. An Analysis of Covariance For Post-Attitude Differences Between Two Instructional Methods With Two Teachers Controlled For Pre-Attitude Test.

SOURCE OF VARIATIONS	SUM OF SQUARES	DEGREES OF FREEDOM	MEANS SCORE	F
Within Cells	17250.309	101	170.795	
Teacher	236.324	1	236.324	2.384
Method	893.102	1	893.102	5.229
Teacher and Method	442.332	1	442.332	2.590

Hypothesis 4. (When the results of the course evaluation of the experimental and control groups are compared, no significant difference will be found.) An analysis of variance was computed on the means as shown in Table 9. The test for homogenity of variance was not satisfied.

Table 9. Means and Standard Deviations For Course Evaluation With Two Factors, Teacher and Method.

FACTORS				VARIABLE
TEACHER	METHODS	STUDENTS	MEAN STANDARD DEVIATION	COURSE EVALUATION
1	Experimental	22	M SD	110.591 9.879
1	Control	39	M SD	110.821 17.812
2	Experimental	24	M SD	111.042 21.267
2	Control	21	M SD	109.143 16.316

The results of the analysis are illustrated in Table 10. There were no F values of significance at the .05 level. Inspection of the means indicated that the experimental group shown is a higher level, but not significantly. The hypothesis was accepted.

Table 10. An Analysis of Variance For Course Evaluation Differences Between Two Instructional Methods With Two Teachers.

SOURCE OF VARIATIONS	SUM OF SQUARES	DEGREES OF FREEDOM	MEANS SQUARE	F
Within Cells	29832.574	102	292.476	
Teacher	8.777	1	8.777	0.030
Method	12.873	1	12.873	0.044
Teacher and Method	28.252	1	28.252	0.097

Hypothesis 5. (When the results of the teacher evaluation of the experimental and control groups are compared, no significant differences will be found.) Table 11 shows the means and standard deviation used in the analysis of variance. The variance satisfied the homogeneous requirement for the analysis of variance program.

Table 11. Means and Standard Deviation For Teacher Evaluation With Two Factors, Teachers and Instructional Method.

FACTORS			VARIABLE	
TEACHER	METHOD	STUDENTS	MEAN STANDARD DEVIATION	TEACHER EVALUATION
1	Experimental	22	M SD	43.273 10.166
1	Control	39	M SD	47.359 10.888
2	Experimental	24	M SD	55.292 15.409
2	Control	21	M SD	49.667 14.252

The results of the analysis of variance for teacher evaluation is shown in Table 12. There was no significant F value between the two levels of the independent instructional variable. However, an F of 7.499 at the .05 level was significant for the two levels of the independent teacher variables. In testing the final null hypothesis for a relationship between the dependent variable (teacher evaluation) and the two independent variables, an F ($p < .05$) of 3.703 was significant. Since the hypothesis was testing for differences between the two levels of the independent instructional variable, the results must reflect this. The hypothesis was accepted.

Table 12. Analysis of Variance For Teacher Evaluation
With Two Factors, Teacher and Instructional Method.

SOURCE OF VARIATIONS	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
Within Cells	16198.980	102	158.814	
Teacher	1190.905	1	1190.905	7.499*
Method	1.208	1	1.208	0.008
Teacher and Method	588.020	1	588.020	3.703

Summary

The purpose of this study was to determine if the instructional approach in modular form was more effective than the traditional lecture approach. The study planned to compare the achievement gain and attitude change of the students in the two instructional approaches. The hypotheses tested were to assist in the solution to a problem at Miami-Dade Community College, North. That problem was in general education, specifically in physical science. Should the modular approach be available to students in physical science at Miami-Dade Community College? What are the guidelines or results of this project?

Hypothesis 1. In the analysis of the results on the pre-to-post achievement test, the results were not significant. However, in the analysis of covariates on the achievement test, using GPA as the covariate, the modular system was significantly better. The teachers influence was also significant in the GPA results. Testing the two teachers experimental post-achievement means with a t-test indicated the two means did differ significantly. One teacher contributed to a high degree to the experimental high mean results. The hypothesis was accepted.

Hypothesis 2. The second hypothesis indicated that modular teaching does not produce better final grades than the traditional system. Yet, the mean results were still in favor of the modular system, but not significantly. The second hypothesis was accepted.

Hypothesis 3. The third null hypothesis was not accepted. The change in attitude of the modular method was significant at an F value of 5.229 ($p \angle .05$).

Hypothesis 4. There was no significant difference between the experimental and control group on the course evaluation was an accepted hypothesis. However, it should be noted that the course evaluation was the last test conducted. The students in both the control and experimental groups had developed by this time an antagonistic attitude toward survey forms. This was observed by the instructors. This may subjectively have affected the course evaluation.

Hypothesis 5. There was no significant difference between the experimental and the control group on the teacher evaluation was an accepted hypothesis. The results indicated one teacher was favored. The mean values were considerably higher for one teacher as evaluated by both instructional groups.

CHAPTER V

IMPLICATIONS AND SIGNIFICANCE

This chapter will present a brief history of the modular development at Miami-Dade Community College, its present status, and future development.

Brief History

The ground work for his project began in 1973-74 with the teaching of the physics classes by individualized instruction which had no lecture classes. By 1975 the individual or personalized instruction had been reduced from four hundred students to approximately thirty per semester. From this abandoned program, salvaged ideas submerged. This salvaging developed the modular idea. Another motivating idea was to have enough modules to provide students with an opportunity to select the topics. The module was an instrument to present topics with objective guidance. By the Fall of 1975 some modules were written on a limited basis and a formative evaluation was initiated in a pilot program. By the Winter semester (1975-76), a summative evaluation was started in a pilot program. This pilot program was culminated into this paper.

Present and Future Status

The modules were attempted in two classes in the Fall Term in 1976 in a pilot program. During the Fall Term (1975) more faculty members volunteered to assist in module writing. Three additional modules were produced. However, the modules are being continued in the Spring and Summer Terms with the same statistical instruments. Implications from all faculty committees and administrators are that the program will be sustained in the Fall Term 1976-77. An indication of this was the fact that another faculty colleage has been granted six credit hour release time during the Spring and Summer to augment the project team of writers.

The mini-course faculty committee has the modules under study. However, difficulty has developed in the administration or registrar area of development. Plans are to utilize the modules as mini-courses when the record keeping problem has been solved. The modules are also being used at Florida Memorial College in a pilot program. The program only involves a survey evaluation.

Analysis of the data has indicated that given a semester of instruction, students were able to gain as much or more achievement in a modular course as they were to gain using the traditional method. The modules are being continued and the statistical analysis is being made. The attitude test is being enlarged so that more areas of opinion can be investigated. Stocker (1976) has used a ninety-nine question attitude test, in the Fall Term of 1975, to investigate attitude in detail. This test will analyze attitude in more areas such as interest in science, intellectual and emotional attitudes in science, etc. A special computer program had to be developed in order that this test could be utilized, but this fact eliminated use of the test for this semester. There was an indication from the data also that some teachers may be more effective in a modular instructional approach. Further study and statistical inference need to be continued in this direction.

The situation developing at Miami-Dade Community College, North, has produced a unique challenge in that it has brought into sharp focus the general education problem prevalent throughout the country. It is not unreasonable to hope that any progress made here might be quite relevant to colleges across the nation.

BIBLIOGRAPHY

51

BIBLIOGRAPHY

American Institute of Physics for Project Physics. Personal correspondence between Donald Emmonds, Field Director, and the author, January to November, 1975.

Allen, Richard A. "Comparison of Two Laboratory Methods Investigating Interest and the Understanding of the Process of Science in a General Education Physical Science Class." Unpublished Ed.D. dissertation, University of Northern Colorado, 1975. (International Dissertation Abstracts 36/7 /4379-A).

Anderson, Elaine. "Non-Science Majors. . . Another Word", Journal of College Science Teaching, 3 (May, 1974).

Baxter, Kendall. "A Comparative Study of the Effectiveness of Three Methods of Teaching a General Education Physical Science Course". Unpublished Ed.D. dissertation, Colorado State College, 1968. (International Dissertation Abstracts 28/9/3395-A).

Beam, Kathryn. "Contemporary Topics In Science", Journal of College Science Teaching, 3 (May, 1974).

Beers, R. B. "Use of Activity-Centered Mini Courses to Solve Difficult Educational Problems". Science Teacher, 40 (September, 1973), 26-9.

Bloom, Benjamin S., et al. Taxonomy of Educational Objectives, Handbook I: Cognitive Domain. New York: David McKay, 1956.

Bloom, Benjamin S. "Learning for Mastery". UCLA Evaluation Comment 1 (2), May, 1968.

Bloom, B. S. "Innocence in Education", School Review, (May, 1972), 333-352.

Browner, W. "Comments Concerning: How to Choose a Theory: Science for Nonscientists", American Journal of Physics, 43 (February, 1975) 182-5.

Calandra, Alexander. "Science For Non-science Majors", Journal of College Science Teaching, (April, 1972), 35-37.

Champagne, Audrey and Leo E. Klofer." Formative Evaluation in Science Curriculum Development "Journal of Science Teaching, 2 (May, 1974).

Collagan, Robert B. "The Construction (Using Multi-Media Techniques) of Certain Modules of a Programmed Course in Astronomy - Space Sciences for NASA Personnel of the Goddard Space Flight Center", 1970, ERIC: 042601.

Committee on Curriculum Studies, "School Science Education for the 70's", The Science Teacher, 38 (May, 1971), 46-51.

Corey, J. R. and J. S. McMichael. Using Personalized Instruction in College Courses. Meredith Corporation, 1970.

Cothern, C. R. "Teaching Science to Non-Science Majors - Some Attitudes, Ideas, and Approaches", American Journal of Physics, 41 (January, 1973) 8-10.

Cowan, D. J. "Environmental Topic in An Undergraduate Physics Curriculum", American Journal of Physics, 40(December, 1972), 1748.

Dale, Elizabeth W. "Comparative Study of Achievement Between College Students Being Taught In the Traditional Manner and Those Taught With Learning Modules." Unpublished Ed.D. Dissertation, University of Alabama, 1973. (International Dissertation Abstract 33/11/6481-A).

DeWitt, R. A. "More Meaningful College Physics Laboratory for Non-science Majors", Physics Teacher, 10(April, 1972), 211-13.

Diedrich, M. E. "Material to Facilitate the Use of Discussion in Science Teaching", Journal of General Education, 24(October, 1972), 184-7.

Dressler, A. J. "Teaching Without Lectures", Rice University Review. Spring, 1971, p. 9-11.

Elliott, Walt and Carla Lowry. "Kinesiology, the Physics of Sports, and Public Interest", Journal of College Science Teaching, 4 (November, 1975).

Friedman, Charles, et.al. "The Rise and Fall of PSI in Physics at MIT", American Journal of Physics. Vol. 44, (March, 1976,)204-211.

Galewood, Claude. "The Science Curriculum Viewed National", The Science Teacher, 35 (April, 1968), 20.

George, S. "Light Lasers and the Visual Image", Journal of College Science Teaching", 4 (November, 1974).

Green, B. A. "Physics Teaching By the Keller Plan at M.I.T." American Psychologist, Vol. 26, 1971, pp 219-244.

Gross, Bernard. "The Design of An Auto-Tutorial Genetic Course to Increase Scientific Literacy Among Non-Science Majors and Its Evaluation Using a Science-Related Semantic Differential Instrument." Unpublished Ph.D. Dissertation, Syracuse University, 1971. (International Dissertation Abstract 32/8/4442-A).

Hall, John F. "The Use of History of Science Studies With First Year Education Students to Teach Skills Involved in Scientific Thinking." Unpublished Ph.D. Dissertation, Oregon State University, 1972. (International Dissertation Abstracts 31/1/224-A).

Hermann, G. "Learning by Discovery: A Critical Review of Studies", The Journal of Experimental Education, 38(May, 1964), 58-62.

Herrscher, Barton. Implementing Individual Instruction. Houston, Texas: ArChem Publishers, 1971.

Hewitt, Paul. "Conceptual Physics Turning Nonscience Students on to Their Everyday Environment" Physics Teacher, 10(April, 1972), 515.

Hurd, Paul D. and James J. Gallaher. "Goals Related to the Social Aspects of Science, " in Sequential Programs in Science for a Restructional Curriculum, Cleveland: Educational Research Council, 1966, pp 12-18.

Hurd, Paul H. "Scientific Enlightenment for An Age of Science", The Science Teacher, 37 (April, 1970), 13-15.

Johnson, Stuart R. and Rita B. Johnson. Developing Individualized Instructional Material. Palo Alto: Westinghouse Learning Press, 1970.

Keller, F. S. "Goodbye, teacher . . ." Journal of Applied Behavior Analysis, Vol. 1, 1968, pp 79-89.

Koen, B. U. and F. S. Keller. "Experience With a Proctorial System of Instruction", Engineering Education, Vol. 62, 1971, 504-505

Krathwohl, David R., et.al. Taxonomy of Educational Objectives, Handbook II: Affective Domain. New York: David McKay Co., 1964.

Mager, Robert F. Preparing Instructional Objectives. Palo Alto: Fearon Publishers, 1962.

Mager, Robert. Developing Attitude Toward Learning. Palo Alto: Fearon Publishers, 1968.

McGuire, J. H. "Teaching Cultural Physics to Texas Aggies", American Journal of Physics, 40 (November, 1972), 1587-89.

Milson, J. L. "Science and the Below Average Student: the Effect of Curriculum Materials on Attitudes", Journal of Experimental Education, 41 (April, 1973), 37-48.

National Science Teacher Association. Theory in Action. Washington, D. C., 1964, pp 8-9.

Olsen, Robert C. "A Comparative Study of the Effect of Behavioral Objectives on Class Performance and Retention in Physical Science". Unpublished Ph.D. Dissertation, University of Maryland, 1972. (International Dissertation Abstracts, 31/1/224-A).

Osgood, C. E., et. al. The Measurement of Meaning. Urbana: University of Illinois Press, 1957.

Pella, Milton O. "Silver Symposia: The Next 25 Years", *The Science Teacher*, 36 (April, 1969), 14.

Popham, W. James. *Educational Statistics*. New York: Harper and Row, 1967.

Rabinovitch, Eugene. "Science and Humanities in Education", *American Association of University Professors Bulletin*, 44 (1958), 449-464.

Roeder, J. L. "A Humanistic Approach to Science", *American Journal of Physics*, 40 (November, 1972), 1615,-17.

Romer, A. A. "How to Choose a Theory: Science for Nonscientists", *American Journal of Physics*, 41 (August, 1973), 947-9.

Rossing, Thomas D. "Physics for Musicians", *American Journal of Physics*, 39 (December, 1971), 1480-82.

Roueche, John E. and Burton R. Herrscher. "A Learning Oriented System of Instruction", *Junior College Journal* 41(2) (October, 1970),p.24.

Rowbotham, Noel. "The Comparison of An Auto-Tutorial Laboratory and a Traditional Laboratory in Physical Science". Unpublished Ed.D. Dissertation, University of Arkansas, 1969. (International Dissertation Abstracts 30/7/2730-A).

Scriven, M. The Methodology of Evaluation. In R. W. Tyler, R. M. Gagne and M. Scriven (Eds) *Perspectives of Curriculum Evaluation*. Chicago: Rand-McNally, 1967, pp. 39-83.

Shamos, Morris. "The Price of Scientific Literacy", *National Association of School Principals*, 47(1963),41-51.

Simpson, Elizabeth. *The Classification of Educational Objectives, Psychomotor Domain*, Unpublished project research, University of Illinois, 1966.

Simpson, Faril. "The Effect of the Laboratory in Achieving General Education Objectives in a College Physical Science Course." Unpublished Ed.D. Dissertation, University of Arkansas, 1969. (International Dissertation Abstracts 29/9/2915-A).

Skinner, B. F. Schedules of Reinforcement. New York: Appleton, 1957.

Slapar, F. M. "Modularized Physics Instruction Is Made to Order for Tech Students", School Shop, 34 (November, 1974), 60-2.

Smith, Melvin. "A Comparison of Two Laboratory Methods for the Teaching of General Physical Science at the College Level: Vicarious Experimentation Versus Conventional Experimentation." Unpublished Ed.D. Dissertation, Pennsylvania State University, 1971 (International Dissertation Abstracts 32/9/5116-A).

Snider, J. G. and C. E. Osgood (eds). Semantic Differential Technique. Chicago: Aldene Publishing Co., 1969.

Soxman, K. A. "Mini Physics at South Missouri State College", Physics Teacher, 10 (September, 1972), 339.

Spears, J. D. and C. E. Hathaway. "Student Attitudes Toward Science and Society", American Journal of Physics, 43(April, 1975), 343-8.

Stekel, Frank. "The Effects of Increasing the Student Involvement in a College Physical Science Laboratory Program". Unpublished Ed.D. Dissertation, Indiana University, 1970. (International Dissertation Abstracts 31/11/5880-A).

Stocker, Carl. "Student Attitudes Toward Science Before and After Introductory College Physics Courses." Unpublished Ed.D. Dissertation, Nova University, 1976. On file at Nova.

Toffler, J. Future Shock. Beverley Hills, California: Glencoe Press, 1972.

Uritam, R. A. "War, Peace, Science and Technology in the Atomic Age -- A Physics Course for the General Student", American Journal of Physics , 40 (September, 1972), 1324.

Uritam, R. A. "Mini-Courses in Physics". Journal of College Science Teaching 3 (December, 1973), 137-38.

Vinson, James J. "Toward the Year 2000, An interdisciplinary Course on the Future", Journal of College Science Teaching, 9 (September, 1975), 29-31.

Welch, W. W. "Review of the Research and Evaluation of Harvard Project Physics", Journal Research in Science Teaching, 10, No. 4(1973), 365.

Whitten, Maurice M. "Changes In Understanding of the Nature of Science and in Critical Thinking Resulting from Two Different Physical Science Courses." Unpublished Ed.D. Dissertation, University of Northern Colorado, 1975. (International Dissertation Abstracts 32/3/1363-A).

Wilson, John T. "Process of Scientific Inquiry: A Model for Teaching and Learning Science", Science Education, 58 (1974), 127-133.

Winer, B. J. Statistical Principles in Experimental Design. New York: McGraw-Hill, 1962.

Wood, Elizabeth. "What Do Nonscience Students Like About Science Courses?", American Journal of Physics, 41 (January, 1973), 156.

APPENDIXES

APPENDIX A

PROFESSIONAL CONTRIBUTORS
TO THE MODULAR DESIGN

PROFESSIONAL CONSULTANTS *

Tech Physics Project
Project Coordinator
Dr. Philip DiLavore
Indiana State University
Terre Haute, Indiana 47809

Tech Physics Project
Field Test Coordinator
Donald Emmons
American Institute of Physics
335 East 45th Street
New York, New York 10017

PHYMOD Consortium
Dr. Frank Six
Department of Physics and Astronomy
Western Kentucky University
Bowling Green, Kentucky 42101

Dr. Philip I. Connors
Chairman, Division of Environmental
and Natural Science
Northern Virginia Community College
3001 Old Bridge Road
Woodbridge, Virginia 22101

* Contributors to modular design.

APPENDIX B

LIST OF MODULAR TOPICS SUGGESTED BY DEPARTMENTS

63

LIST OF MODULAR TOPICS SUGGESTED BY DEPARTMENTS

MODULE	DEPARTMENT
A-B-C's of Relativity	PHY
Adaptation	BIO
Alcoholism	CHM
Amphibians or Reptiles of South Florida	BIO
Architecture of Matter, The	CHM
Animal Behavior	BIO
Astrology, Astronomy & You	GEL
Astrology - How It Started, What it Means	GEL, PHY
Astronomy Today	PHY
Atoms: Are They For Real?	CHM
Automobile Physics	PHY
Biochemical Effects of Alcohol	CHM
Biogeography of Florida	BIO
Biology & Chemistry of Wine, Bread and Cheese	BIO & CHM
Birds of South Florida	BIO
Breath of Life, The	CHM
Care and Abuse of Natural Resources	GEL
Chemical Properties of Alcohol	CHM
Chemistry - Where the Action Is	CHM
Chemistry and Life - How Did We Happen?	CHM
Chemistry Can Get You	CHM
Chemistry Can Make You Beautiful	CHM
Chemistry of Brewing	BIO
Chemistry of Cosmetics	CHM
Chemistry of Drugs - Do They Turn You On or Off?	CHM
Chemistry of Food Additives	CHM
Chemistry of Life For The Living	CHM
Chemist's Bible, The	CHM

LIST OF MODULAR TOPICS SUGGESTED BY DEPARTMENTS (cont'd)

Communicable Diseases	BIO
Computers and A.P.L.	PHY
Conduct of Science: Values, Priorities & Choices	PHY
Consumer Science	PHY
Contemporary Problems of Human Health	BIO
Contribution of Minority Groups in An Expanding Universe, The	PHY
Cool and Supercool - Study of Hot and Cold	PHY
Day After Buck Rogers, The	PHY
Do Calories Count? The Chemistry of Eating	CHM
Drugs - To cure, To Calm, To Kill	CHM
Earth - Past, Present and Future, The	GEL
Ecology - What?	BIO
Electricity - Man's Servant	PHY
Endocrines	BIO
Energy Crisis, The	CHM
Environment	BIO
Environmental Health	INTER
Environmental Safety In the Home	INTER
E.S.P. - Does It Really Work	PHY
Essential Elements, The	CHM
Evolution	BIO
Everything You Wanted To Know About Physics But Were Afraid To Ask	PHY
Extra - Terrestrial Chemistry - Is There Life on Mars?	CHM
Fallout - Where We Stand	PHY
Feast or Famine - The Science of Agricultural Chemistry	CHM
Field Studies in Geology	GEL
Form and Function	BIO
Fossil Life and Geologic Time	GEL
Gems and Gem Material	GEL
General Description of Everything, A	PHY
Genetics	BIO
Go-Go Electrons, The	CHM

LIST OF MODULAR TOPICS SUGGESTED BY DEPARTMENTS (cont'd)

Gravity	PHY
Hoaxes Perpetrated In the Name of Science	PHY
Homeostasis	BIO
How Heavy Is it - Theory of Weight Measurement	INTER
How Long Is It - Theory of Measurement	INTER
How Much Is Too Much? Measurements	PHY
Human Evolution	BIO
Human Genetics	BIO
Human Nutrition	BIO
Human Reproduction & Contraception	BIO
If It Squeaks, Oil It - A Study of Friction & Motion	PHY
Industrial Uses of Alcohol	CHM
Man's Future In the Universe	GEL
Matter and Antimatter	PHY
Matter in Motion	PHY
Marine Life of The Florida Coast	GEL
Mechanical Advantage - Leverage	PHY
Molecules of War	CHM
Moral Dilemma of Science	PHY
National Parks	GEL
Observation in Modern Astronomy	GEL
Observing the Sky	PHY
Oceans - A Chemical View, The	GEL
Oceans - A Biological View, The	BIO
Oceans -A Geological View, The	GEL
Oceans - A Physical View, The	GEL
Ocean Environment of South Florida	GEL
Our Dirty Air	GEL
Ordering the Elements	CHM
Out, Out Damned Spot - Chemistry of the Home	CHM
Pesticides and Other Dangerous Chemicals	BIO & CHM
Philosophy of Science	INTER

LIST OF MODULAR TOPICS SUGGESTED BY DEPARTMENTS (cont'd)

Physics and the 5th Dimension: Society	PHY
Plants and Civilization	BIO
Pollution - How Sciences Can Help	INTER
Pollution and Chemistry	CHM & GEL
Population Dynamics - Abortion, Euthanasia, and People	BIO
Power Sources	PHY
Power Crises	GEL
Prehistoric and Modern Life of Florida	GEL
Properties of Metals	CHM & PHY
Radioactivity and Nuclear Energy	PHY
Radiation Doesn't Tickle - But Fortunately is Quite Photogenic	PHY
Reflections on Science and Politics	PHY
Reproduction	BIO
Science Behind Art, The	INTER
Science for Musicians	BIO
Sinkholes, Caves and Springs in Florida	GEL
SST's to UFO's	PHY
South Florida's Dirty Water	GEL
Types of Alcohol	CHM
UFO'S Fact or Fiction	PHY
Vertebrate Animals	BIO
Volcanoes, Earthquakes and Drifting Continents	GEL
Water, Water Everywhere and Not a Drop to Drink	CHM
Water Resources of South Florida	GEL
Waves, Light and Sound	PHY
Weather For Boaters	GEL
Weather for Flyers	GEL
Weather of South Florida	GEL
What an Alcohol is?	CHM
Where There's Life There's Carbon	CHM
You are What you Eat	CHM
You are What Your Kidneys Keep	BIO, CHM

APPENDIX C

RESULTS OF STUDENT SURVEY
INDICATING PREFERENCE OF TOPICS FOR MODULES

RESULTS OF STUDENT SURVEY
INDICATING PREFERENCE OF TOPICS FOR MODULES

NUMBER OF VOTES*	MODULE TITLE
303	Human Reproduction
228	Ecology - What?
201	You are What you Eat
199	Animal Behavior
196	Gravity
186	Observing the Sky
173	Contemporary Problems of Human Health
172	Genetics
169	Evolution
147	Biology of Wine, Bread and Cheese
142	Population Dynamics
135	Water Resources of South Florida - Field Trips
134	The Breath of Life
126	Age of Dinosaurs
118	Do Calories Count?
117	Food Additives
115	Volcanoes-Past, Present and Future
115	The Ice Age
106	Consumer Science
105	Pollution and Chemistry
94	Feast or Famine
91	Animal Diversity
91	Weather Maps
90	Pesticides & Dangerous Chemicals
90	Light - The Science Behind
89	Weather for Boaters
88	Plants and Civilization

* Number of votes indicating preference.

RESULTS OF STUDENT SURVEY (cont'd)

NUMBER OF VOTES	MODULE TITLE
82	Biogeography of Florida
82	Care and Maintenance of One Small Planet
79	Continental Drift & Mountain Building
78	Radioactivity & Nuclear Energy
77	Matter & Anti-Matter
76	Chemistry in Photography
73	Coal & Supercoal
63	Energy Crisis
56	Chemistry & Life
54	Physics & The Fifth Dimension Society
52	Electricy - Man's Servant
41	Atoms - Are They For Real?
39	Power Sources
38	ABC's of Relativity
37	Extra - Tenestrial Chemistry
26	Endocrines
25	Where There's Life There's Carbon
25	Theory of Measurement
	STUDENT SUGGESTIONS
2	U.F.O.'s
1	Man In Space
1	Astrology
1	Science & Athletics
1	Dangerous Drugs & Their Effects

APPENDIX D

MODULE EVALUATION SURVEY
STUDENT FORM

MODULE EVALUATION SURVEY - STUDENT FORM

TO THE STUDENT: You have been studying material newly developed by the Physics Department. If you would take the time to answer the following questions thoughtfully, it would be a great help to the writers in revising the materials. Thanks for your help.

I. General Information

1. Module Used (Title) ______________________________
2. School ______________________________
3. Instructor ______________________________
4. Time spent on module: Hours of class __________; Hours of lab __________; hours of outside study ______________ number of weeks ______________________________
5. What program are you enrolled in? (For example, 2 year electronics tech., 4 year engineering tech., liberal arts, etc.) ______________________________
6. Is this physics course required in your program? __________ or an elective? ______________________________
7. What grade do you expect to get in the course? (A,B,C,D,F) ___
8. Approximately what is your present grade average? __________

II. The Module

1. How much of what you learned in the module has practical value?
   - ( ) Almost all.
   - ( ) Not all, but more than half.
   - ( ) Some, but less than half.
   - ( ) Almost none.
2. How much of the module did you find interesting?
   - ( ) Almost all.
   - ( ) Not all, but more than half.
   - ( ) Some, but less than half.
   - ( ) Almost none.

3. How much of the reading did you find easy?
   ( ) Almost all
   ( ) Not all, but more than half.
   ( ) Some, but less than half.
   ( ) Almost none

4. How much of the mathematics used in the module could you understand as you read the material?
   ( ) Almost all
   ( ) Not all, but more than half
   ( ) Some, but less than half.
   ( ) Almost none.

5. As you worked your way through the module, how much of the material did you understand?
   ( ) Almost all.
   ( ) Not all, but more than half.
   ( ) Some, but more than half.
   ( ) Almost none.

6. How much of the laboratory part of the module was helpful to you in understanding the concepts, principles and laws developed in the module?
   ( ) Almost all.
   ( ) Not all, but more than half.
   ( ) Some, but less than half.
   ( ) Almost none.

7. We have been calling the abilities, skills, and knowledge which we assume that you know before starting a module prerequisites. In how much of the module did you find a need for prerequisites which had NOT been included in the list of prerequisites?
   ( ) Almost all.
   ( ) Not all, but more than half.
   ( ) Some, but less than half.
   ( ) Almost none.

8. How many of the prerequisites in the list were written so that you could tell what you needed to know before starting the module?
   ( ) Almost all.
   ( ) Not all, but more than half.
   ( ) Some, but less than half.
   ( ) Almost none.

9. The abilities, skills, and knowledge which you are to learn from a module are described in the list of objectives. How many of the objectives were written so that you could tell precisely what you were expected to learn in the module?
   ( ) Almost all.
   ( ) Not all, but more than half.
   ( ) Some, but less than half.
   ( ) Almost none.
10. How much of the module helped you to meet those objectives?
   ( ) Almost all.
   ( ) Not all, but more than half.
   ( ) Some, but less than half.
   ( ) Almost none.
11. How much of the post-test emphasized those things the objectives had stated that you should learn from the module?
   ( ) Almost all.
   ( ) Not all, but more than half.
   ( ) Some, but less than half.
   ( ) Almost none.
12. What topic(s) in the module did you find most interesting?

13. What topic(s) in the module did you find least interesting?

14. Which activity did you enjoy most? (A particular lab, lecture, demonstration, reading, calculations, discussions, etc.)

15. Which activity did you enjoy least?

16. Other comments?

APPENDIX E

MODULE EVALUATION SURVEY RESULTS

MODULE EVALUATION SURVEY
RESULTS
STUDENT FORM

QUESTIONS	ASTRONOMY	LONGER YARD	AUTOMOBILE COLLISION	ENERGY & HEAT
1.	2.3 *	2.8	2.6	2.7
2.	2.1	2.7	2.4	2.8
3.	2.04	2.1	2.9	2.4
4.	1.6	2.1	2.7	2.6
5.	1.8	2.2	3.1	2.7
6.	1.8	2.7	2.2	2.6
7.	3.3	3.3	3.2	2.7
8.	2.3	2.5	2.1	1.8
9.	2.0	1.9	2.1	1.9
10.	2.0	2.6	2.1	2.7
11.	1.8	2.7	2.2	2.7

---

* These numbers are the mean response to the questions on the formative evaluation survey given to students. All questions should tend to a low mean for good results, except seven where results, if good, should have a high mean. Answer choices were from one to four.

APPENDIX F

MODULE EVALUATION SURVEY

TEACHER FORM

MODULE EVALUATION SURVEY - TEACHER FORM

After your students have completed a science module, we most earnestly solicit your cooperation in filling out this questionnaire and in having your students fill out the student evaluation form. It is only through the feedback provided by your throughful and honest answers that we can improve the module before it goes into its final form. Thank you.

I. General Information

1. Name of module ______________________________
2. Instructor ______________________________
3. School ______________________________
4. Dates module was used ____________ to ____________
5. Number of classroom hours spent on module ______________

   Weeks spent ______________________________
6. Number of students in class ______________________
7. Were they all in technology programs? ______________

   If not, what was the breakdown? ______________

II. The Module

A. Prerequisites and Objectives

1. Were the prerequisites and objectives clearly stated?

2. If a student satisfied the prerequisites, was he really ready for the module? Underprepared? Overprepared?

3. Were the stated objectives the same as the actual objectives of the module as you perceived them? If not, please be specific.

4. Are the stated objectives valid in terms of what you believe that your students should learn?

5. Are there other objectives which you believe are important and can be taught in this module? If so, please attach statements of these objectives and tell where in the module they can be taught?

6. Did the objectives help you to know in advance what would be expected of the students?

7. Did they help the students?

8. Did the post-test measure achievement of stated objectives? How did students do? Please attach a copy of the test with an item analysis (number of students scoring each item correctly.)

9. In teaching this module, what, if anything, did you do beyond the prescribed work?

B. The Text

1. Is the text clear? At about the right level?

2. Is the math at about the right level?

3. Is the text interestingly written?

4. Is the amount of work required about right for the time allotted?

5. Specifically where are there difficulties with the text? (If you have marked-up a copy of the text, it would serve admirably to answer this question.)

C. The Laboratory Exercises

1. Are the labs central in the development of concepts, or are they used to verify relationships?

2. What is the best experiment? The worst?

3. Were experiments designed for the appropriate amount of lab time per week?

4. Is the equipment provided or suggested for each experiment adequate for the purpose?

5. Are the laboratory instructions clear and do they contain the right amount of detail?

6. In your judgement what did the experiments emphasize? (Observation, measurement, verification, investigation)? Were these emphases appropriate?

7. Which experiments are appropriate to the textual content of the module? Which are inappropriate?

III. The Module Approach

1. What are the best features of this approach in teaching physics?

2. What are the worst features?

3. Do you personally enjoy teaching in this mode?

4. Did your students enjoy learning this way more than from the conventional text?

5. In your judgement did they learn more or less from modules than they would have in the same amount of time using a conventional text?

6. If sufficient modules of this type were available, could you use them without an accompanying text, as the basis for an entire physics course?

7. If the answer to (6) is yes, would you WANT to use a set of modules as the basis for a course? Why or why not?

8. If the answer to (6) is no, why not?

9. Any other comments?

APPENDIX G

MODULE SAMPLE

A LONGER YARD

INTRODUCTION

With Great Britain, Canada, Japan, Australia, Africa changing to metric in the past ten years, over 90 percent of the earth's population is in countries using metric. America must also think metric to be competitive in the world market. Metric standards can and have been used as a marketing bloc against the USA by the common market group. France has enacted a law prohibiting the import of non-metric products. Some countries have been requiring that imported goods be subject to a metric standard test at the expense of the shipper. These tests increase costs and retard the sale of goods.

Metric is coming to America. It is no longer a question of when will the metric system come...the only remaining question is, "How will the conversion be completed?" Ford Motors, General Motors, IBM, Honeywell and Caterpillar have established programs to complete their conversion. Food products now have metric quantities on the label if you observe this. The main problem in completing this conversion is primarily one of public education. How can the people of America be taught to think in meters instead of feet, in liters instead of quarts, and in Newtons instead of pounds? This module is designed to help you to think in the metric system.

PRE-REQUISITES

The only pre-requisite needed for this module is fundmental arithmetic.

PRE-ASSESSMENT

Your instructor has a test on this module if you wish to assess your present knowledge.

LEARNING GOALS

Section A

After working and observing in this module, the student will be able to:

1. Estimate lengths using centimeters and meters.
2. Demonstrate the ability to make measurements using the metric units of length.
3. State units and relationships among the metric units of measure.
4. Change a metric linear measure from one unit to another within the system.
5. Write the abbreviations for metric linear units of measurement.
6. Convert a metric square measure from one metric unit to another, and be able to estimate common areas.
7. Convert a metric cubic measure from one metric unit to another, and be able to estimate common three dimensional objects.

Section B

The section will develop awareness in the metric system of volume. With this section the student will be able to:

1. Have a working knowledge of the unit of liquid measure and volume measure in the metric system.
2. Estimate volumes of common containers.
3. Measure volumes of liquid containers.

Section C

With the completion of this module's activities, the student will be able to:

1. State the units of mass of the metric system in order.
2. Estimate the mass of common objects.
3. Determine the mass of selected objects.
4. State the units of force in the metric system.
5. Convert mass units to force units.
6. Measure some common forces in newtons.
7. Estimate the weight of some objects in newtons.

SECTION A

Introduction

One of the advantages of changing to the metric system is that it is relatively easy to learn. But there is another important reason for adopting the metric system. If we don't, very soon we will not be able to talk to the rest of the world. The language of the world's technology is written in the metric system.

You needn't wait for your country to complete its conversion to the metric system before you put this system to practical use. You will find many of these units useful to you right now...particularly if you are studying any field of science, engineering, business, nursing, or travel in a foreign country. But even if you don't do any of these things, you will need to know what these metric units are so you can understand the articles you'll be seeing more and more frequently in newspapers and magazines as we go completely metric.

The New System

Now let's look at the metric system. Each unit smaller than the meter is one-tenth of the next larger unit, and each unit larger than the meter is ten times the next smaller unit. Such a system is referred to as a decimal system.

Units of Length in the Metric System

10 millimeters (mm) = 1 centimeter (cm)
10 centimeters = 1 decimeter (dm)
10 decimeters = 1 meter (m)
10 meters = 1 dekameter (dkm)
10 dekameters = 1 hectometer (hm)
10 hectometers = 1 kilometer (km)

Measuring

A dime is about 1 mm thick. Of course ten dimes is 1 centimeter thick.

A shirt button is approximately 1 centimeter wide.

A small centimeter ruler is on the bottom of this page. Measure objects and complete the chart.

__________ Width of little finger

__________ Length of little finger

__________ Width of hand

__________ Length of nose

__________ Circumference of little finger

__________ Length of pencil

Estimate:

__________ Thickness of pencil

__________ Width of popsicle stick

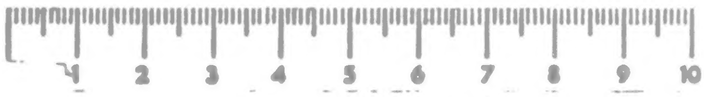
__________ Width of standard ruler

__________ Width of watch crystal

__________ Width of door handle

__________ Thickness of penny

__________ Width of a piece of writing paper



Combining meters and centimeters.

Meters and centimeters can be combined without using both words. For instance, a measurement of 1 meter plus 60 centimeters may be written 1.68 meters. Examine a meter stick. Do you see that one meter contains 100 centimeters? How many meters are in 200 centimeters? 300 centimeters? 900 centimeters? Did you count the number of millimeters in a meter? Or do you understand 10 mm = 1 cm and 100 cm or 1 meter = 1000 mm?

Examples:

1 meter and 30 centimeters = ____________________

3 m and 60 cm = ____________________

12 m and 4 dcm = ____________________

1.5 m and 20 cm = ____________________

528 cm = ______m + _______cm

340 cm = ______m + _______cm

217 cm = ______m + _______cm

Long Distance

There is a better unit for long distances. The kilometer is equal to 1000 meters. Your instructor will indicate to you where a measured kilometer is located. It is equal to about ten football fields.

1 kilometer = 1000 meters

_______km = 4000 m

5 km = _______m

_______km = 11,000 m

15 km = ______m

_______km = 34,360 m

Your instructor may wish you to finish the following table:

	Chicago	San Francisco	Washington D.C.	Philadelphia
Miami				
Chicago				
Los Angeles				

Distance between cities in kilometers

Building a ladder of units.

Choose the longer of the following:

1 km, 1 m = ____________

1 m, 1 cm = ____________

1 cm, 1 km = ___________

1 mm, 1 cm = ___________

1 mm, 1 m = ____________

1 m = __________mm

1 m = __________cm

1 cm = _________ mm

1 km = _________ m

Write the other units of linear measure other than the mm, cm, m, and km. _________, _________, ________ (abbreviate)

To change from a longer linear unit in the metric system to the next shorter one, you multiply by _________. Change 1 km to 10 hm.

3 km = ________hectometer (hm)

2 km = ________dkm

4 m = ________dm

5 dm = ________cm

7 cm = ________mm

To change from a short linear unit in the metric system to the next longer unit, you divide by __________.

8 m = .8 dkm

8000 m = _______dkm

100 mm = _______cm

.01 dkm = ______km

10 cm = _______dm

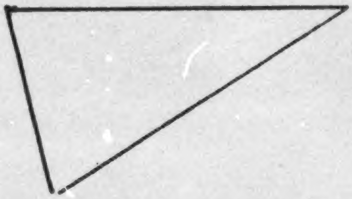
1 cm = ________m

.1 m = ________dkm

.001 km = ______km

Squaring things up

Area is a measure of _______and _______. Take your centimeter ruler and construct a 2 cm by 4 cm rectangle, another 10 cm by 10 cm. Measure this area in centimeters.



Observe your 10 cm by 10 cm square. The area is 100 sq. cm = 1 sq decimeter. It is called a squared decimeter, because each side of the square is 1 decimeter.

500 sq cm = ________sq dm　　　　_____sq. cm = 6 sq dm

223 sq cm = ________sq dm　　　　_____sq cm = 31 sq dm

Summary

1 sq dm = 100 sq cm

1 sq m = 10,000 sq cm

1 m^2 = 100 dm^2

To change from a larger square unit to the next smaller square unit, you multiply by ______. Complete these statements:

4 km^2 = ______dkm^2　　　　4m^2 = ______dm^2

4dkm^2 = _____m^2　　　　4 dm^2 = ____cm^2

4 cm^2 = _____mm^2

To change from a smaller metric square unit to larger square unit, you divide by ________for each change in units. 200 m^2 = 2dkm

400 m^2 = _____dkm^2　　　　4 cm^2 = ______dm^2

4 dkm^2 = _______km^2　　　　400 mm^2 = _______cm^2

Cube things up

Construct a cube 10 cm x 10 cm x 10 cm. This is 1000 cubic centimeters. Since 10 cm = 1 cm this is 1 cubic decimeter. Realize that each side of the 10 cm cube is equal to 100 mm so 100 mm x 100 mm x 100 mm is 10^6 cubic millimeters. So 1000 cm^3 = 1 dm^3 = 10^6 mm^3

200 cm^3 = _________dm^3

4000 cm^3 = _______dm^3

9000 cm^3 = _______dm^3

4 dm^3 = _______mm^3

7 dm^3 = ________mm^3

444 cm^3 = ________dm^3

Which is larger?

	LARGER
1 cc or cm^3	______
1 cm^3 or 1 dm^3	______
1 dm^3 or 1 m^3	______
1 m^3 or 1 cm^3	______

So:

1,000,000,000 cm mm = _____cu. cm. = 1000 cu dm = _______cu. m.

Mixed Practice

Write correct numbers in the blanks.

4 cu. km = __________cu. cm

4,000,000,000 cu. mm = _________cu. dm.

11,000,000 cm - ______ = 9 cu. m

1000 ________ = 1 cu cm.

3 cu. m. = _______cu. mm.

What is the volume of the following boxes?

	Box 1	Box 2	Box 3
Length	4 mm	1 m.	3 m
Width	5 cm	30 cm	1111 mm
Height	1 m	1000 mm	8 dm
VOLUME:	______	______	______

SECTION B

Construct from heavy paper or visualize the container of your 10 cm x 10 cm x 10 cm cube. This is 1000 cu cm which is 1 liter in volume. So this small container can be filled with sand or water to estimate volume.

Provide the word MORE or LESS in the blanks which follow. Fill your 1000 cu cm container with sand and estimate the following volumes.

A tablespoon holds _________than a liter of sand.

A cup holds ___________than a liter of sand.

An 8 oz. glass holds _____than a liter of sand.

A cereal bowl holds _________than a liter

A one quart milk container holds _______than a liter.

Do you drink a liter of liquid everyday? ___________

Graduated Cylinder.

Find a graduated cylinder in the laboratory. What is the capacity of the graduated cylinder? __________ml. Find the liquid capacity of four different containers provided by your instructor.

CONTAINER	VOLUME
1. ___________	_____________ml
2. ___________	_____________ml
3. ___________	_____________ml
4. ___________	_____________ml

How many milliliters make a liter? _____________

Name two containers that are about 1 liter capacity.

1. _______________ 2. _____________

Name two containers that are less than 1000 ml in capacity.

1. _______________ 2. _____________

The abreviation for a liter is ______________.

Combining liters and milliliters.

Liters and milliliters can be written without using both words. The measurement may be 1.896 liters. This is one liter and 896 milliliters.

Thus - 7845 ml = 7000 ml + 845 ml
= 7 liters + 845 ml
= 7.845 liters

Fill in the blanks.

5284 ml = ___________1 + ________ml

5284 ml = ________1 + ________ml

5284 ml = ___________liters

To change from a smaller metric liquid unit to the next larger metric liquid unit you divide by ________ for each unit passed up the metric system.

40 ml = 4 cl

400 cl = 40 dl

500 liter = ________dkl

400 dkl = ________hl

544 hl = ________kl

24,000 cl = ________dl

9,300,000 ml = ________cl

________cl = 80,000 dl

Mixed Practice

1. 467 ml = ____________liter
2. 456 liter = ________kl
3. 8.642 liter = ________ml
4. 1.064 ml = ________cl
5. 1000 m = ________mm
6. 4560 hl = ________kl
7. 504 liter = __________kl
8. 544 hl = __________dl
9. 10,000 ml = __________kl
10. 5 kl = ________ml

SECTION C

In the laboratory or demonstration room, obtain one of the small plastic buckets and pour in 1000 milliliters of water. Use your graduated cylinder to measure the water. Each person should hold the water-filled bucket in his hand. This mass of the water is about one kilogram. The kilogram is a unit of mass in the metric system. Find three objects in the room which have about the same mass. List the objects:

1. ____________ 2. ____________ 3. ____________

5870 ml = __________ liters

6784 ml = ________ liters

6.65 ml = ___________ liters

8945 ml = _________ liters

A larger volume.

Large tankers and trucks employ a large volume, the kiloliter, which is 1000 liters.

This 1 kl - 1000 liters, so

5 kl = __________ 1

2000 kl = _______ 1

53,000 kl = _______ 1

_______ kl = 7000 1

______ kl = 9000 1

_______ kl = 10,000 1

Building a ladder of units.

Which of the units are greater in volume?

1 liter or 1 m = ___________

1 1 or 1 kl = _______________

500 ml or 1 1 = _______________

1400 liter or 7 kl = _______________

Write other units of volume measure other than the mm, 1, kl,

_______, _______, ________, ________ (abreviate)

To change from a larger unit to the next smaller unit of liquid measure, you multiply by 10.

1 kl = 10 hl

4 kl = _____ hl

1 kl = _______ dkl

8 hl = ________ dkl

1 dkl = ________ 1

4 1 = _________ dl

5 dl = __________ cl

5 cl = ___________ ml

Obtain a graduated cylinder and a medicine dropper. Carefully fill the graduated cylinder so that the water level is even with the highest mark on the cylinder. A 50 ml graduated cylinder is a good size to use. Use the medicine dropper to siphon off exactly one milliliter of water. When you have one milliliter of water in the medicine dropper, squirt the water into your cupped hand. Each student should do this. This 1 ml of water has a mass of one gram. The gram is a basic unit in the metric system. Tear off one-third of a sheet of notebook paper. Crumple it tightly and hold it in your cupped hand. This should have approximately the same mass as the milliliter of water.

Find three objects in the room that have a mass of about one gram.

1. __________ 2. ___________ 3. ___________

Fill in the following chart which is the "ladder" of mass units for the metric system. Remember the prefixes are the same for all types of metric measures.

Grams	Units	Abbreviations
1000	kilogram	kgm
____	_______	dkg
____	gram	g
1/100	_______	cg
______	milligram	_______

Change the following units of mass.

1. 12.5 kg - _______g.
2. 2000 g = _____kg
3. 4000 mg = ______cg
4. 42.1 cg = _____hg
5. 23.1 hg = _______kg
6. 20 mg = ________kg
7. 40 dkg = ______ g
8. 320 cg = _______mg
9. 4320 mg = ______g
10. 5230 cg = ________mg

Mass and Weight

Lift a chair and hold it for a while. What causes the chair to feel so heavy? ______________What force is acting on the chair? ________________ If you performed this experiment on the moon, what difference would you notice? _____________________ Are there places in the universe where the chair would be weightless? ______________The weight of the chair as it has been transported has changed continually, but has the chair itself changed? __________________Does it not contain the same amount of stuff or atoms? _____________Obviously it did not gain or lose matter. The mass of the chair remained the same but the weight changed. Can you see that the chair has two properties? Its weight is the force of attraction between the chair and whatever heavenly body it is located upon, such as the earth. Its mass defines the amount of matter, stuff, or atoms which it is made of. Mass does not change as you move around the universe; weight does change.

Place an index card flat on a table with about one centimeter extending over the edge. Place a penny on the index card. Snap the card (hit it with your finger on the end of the card) so that it slides along the table top. What happened to the coin? ______________________________One measure of the mass of an object is its tendency to remain stationary. Scientists refer to this property as inertia.

A beam balance is used to mass objects or compare the objects to standards. When weighing objects the force of gravity is usually measured by a spring.

Force Units

Push on a wall. You are exerting a force on the wall. Does the wall exert a force back when you push? ________________________ When you are standing still or running on the floor are you exerting a force?
____________________________.

Remember filling the plastic bucket with a liter of water? What was the mass of that amount of water? ______________ That mass of water has a weight of 9.8 Newtons which is the force of attraction the earth has for the object. One kilogram of mass is attracted to the earth by a force of 9.8 Newtons. Two kilograms is attracted by 19.6 (2 x 9.8) Newtons.

Your instructor may wish to explain the connection between Newton's laws and the force of weight. Or you can read an explanation in Poppy's book in Chapter

Complete the chart.

IN GRAMS	IN KILOGRAMS	FORCE IN NEWTONS
150	.15	1.47
200		
250		
300		
350		
500		
1000		
.9		
1.67		

Laboratory C

Obtain a small spring scale for the experiment involving weighing. Use the table which you just completed of grams to newtons and weigh some objects. Complete your table to include the scale of the spring balance. Most of the spring balances weigh from zero to 500 grams. Suspend seven objects provided by your instructor and record.

	OBJECT	NEWTONS
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Estimate the following, then confirm your results by using the spring balance.

OBJECT	ESTIMATED WEIGHT (IN NEWTONS)	MEASURED WEIGHT
Key		
Pen		
Wristwatch		
Nickle		
Quarter		
Yourself (Use large floor scale in lab)		

APPENDIX H

PHYSICAL SCIENCE ACHIEVEMENT TEST

PART I: PHYSICAL SCIENCE COMPREHENSION

Directions: Examine each statement below and decide whether it is true or false. If the statement is true, fill in choice one on the IBM card. If the statement is false, fill in choice two on the IBM card.

1. A barometer is used to measure temperature
2. All gases are lighter than air.
3. Bakelite is a good conductor of electricity.
4. A molecule can be seen.
5. Evaporation produces a cooling effect.
6. Wave motion is found in practically every field of physical science.
7. A boat will sink deeper into the water as it passes from a river into the ocean.
8. A gas completely fills any closed vessel that contains it.
9. Sound may be transmitted through a vacuum.
10. Hydrogen is inflammable.
11. Air is a poor conductor of electricity.
12. One magnetic pole of the earth is at the north geographic pole.
13. A centimeter is 1/10 of a meter.
14. The velocities of falling bodies vary directly as their weights.
15. The bubbles emerging from a diver's suit become smaller as they approach the surface.
16. An opaque substance obstructs the passage of light.
17. Cream has less density than skim milk.
18. The total amount of energy in the universe is constantly changing.
19. Sliding friction is always greater than starting friction.
20. A vacuum is a good conductor of heat.
21. As a body is raised above the surface of the earth the force of gravity pulling it downward becomes smaller.
22. If all forces were eliminated from a moving body it would gradually come to rest.
23. The temperature of the human body is about 37°C.
24. A bimetal strip can be used to actuate a thermostat.
25. Light travels 100,000 miles per second.
26. Increasing the pressure lowers the boiling point of water.
27. Air under extreme pressure liquifies at -140°C.
28. The boiling point of water depends upon the atmospheric pressure.
29. The voltage of a group of cells in parallel is the same as the voltage of one cell.
30. A thick tumbler is less likely to break when hot water is poured into it than a thin one.

31. A non-compensated pendulum of a clock should be lengthened in cold temperatures.
32. Meteorites become luminous as they near the earth chiefly because they are more clearly visible.
33. If thunder follows lightning at an interval of 10 seconds, the flash must have been 10 miles away.
34. Pure water can be cooled below 0°C. without freezing.
35. Pumping more helium into a fully expanded balloon would decrease its lifting power.
36. A thermometer measures the quantity of heat in a substance.
37. A siphon will work in a vacuum.
38. A kilogram is equal to 10,000 grams.
39. All known gases have been changed into liquids.
40. Mercury freezes at about -40°F.
41. Rolling friction is usually greater than sliding friction.
42. The water in a modern steam locomotive boils at 100°C.
43. Bodies weigh more at the pole than they do at the equator.
44. A newly formed cumulus cloud is part of an ascending air column.
45. Moist air is lighter per unit of volume than dry air.

PART II: VERBAL COMPREHENSION

Directions: On this page are thirty-one words in CAPITAL LETTERS. After each word there are five choices of other words, one of which is most nearly equivalent in meaning to the word in capital letters. Select the most appropriate answer and fill in the space on the IBM card.

SAMPLES: X. FLOOD (1) denude (2) deluge (3) buried
(4) delude (5) destroy

Y. IRON (1) animal (2) vegetable (3) social
(4) metal (5) religious

In Sample X, the word "deluge" is most nearly equivalent in meaning to the word "FLOOD." "Deluge" is answer 2; so the space under 2 is filled in on the answer card.

In Sample Y, the word "metal" is most nearly equivalent in meaning to the word "IRON." "Metal" is answer 4; so the space under 4 is filled in on the answer card.

1. REGRESS (1) retreat (2) deviate (3) intrude
(4) rise up (5) transgress

2. TERMINOLOGY (1) termination (2) composition (3) cosmology
(4) nomenclature (5) punctuation

3. INSULATE (1) transfer (2) insular (3) isolate
(4) offend (5) repair

4. DISTILLATE (1) dilute (2) absorption (3) residue
(4) precipitate (5) condensate

5. RHEOSTAT (1) recur (2) resistance (3) an animal
(4) stationary (5) transmitting

6. VELOCITY (1) vertical (2) distance (3) depth
(4) age (5) rate

7. PARADOX (1) seemingly contradictory (2) perfect
(3) old-fashioned (4) a metaphor (5) entrance

8. PHENOMENON (1) model (2) event (3) wish (4) performance
(5) crisis

9. DUCTILE (1) hard (2) liquid (3) rigid (4) flexible
(5) pointed

10. PERIMETER (1) spherical (2) diagonal (3) surface (4) boundary (5) parallel

11. SPECTRUM (1) knife (2) spirit (3) suspicious (4) a sound (5) a range of color

12. IMPULSION (1) turbulence (2) alternation (3) driving force (4) embarkation (5) sublimation

13. EQUILIBRIUM (1) horse drawn (2) unequal (3) kind of library (4) balance (5) convulsion

14. RECIPROCATE (1) to overcome (2) to avenge (3) to interchange (4) to mix (5) to discard

15. REFRACTION (1) increase (2) refutation (3) bending (4) uniting (5) acclaiming

16. CATALYSIS (1) color (2) catacomb (3) charge (4) fumigation (5) activation

17. INCREMENT (1) accusation (2) assessment (3) expense (4) addition (5) discrepancy

18. SUBLIMATE (1) cool (2) subdue (3) elevate (4) regulate (5) combine

19. HYPOTHESIS (1) a supposition (2) relation (3) provision (4) unknown

20. OSMOSIS (1) combining (2) diffusion (3) ossification (4) incantation (5) clarification

21. COLLOIDAL (1) thin (2) mucinous (3) powdered (4) hairy (5) beautiful

22. ELECTRODE (1) officer (2) electrolyte (3) terminal (4) positive (5) election

23. EMIT (1) remain (2) return (3) enter (4) omit (5) discharge

24. PROFICIENCY (1) vocation (2) competency (3) repugnancy (4) prominence (5) urgency

25. BIBLIOGRAPHY (1) description (2) stenography (3) photograph (4) compilation of books (5) topographical sample

26. FIDELITY (1) belief (2) treachery (3) strength
(4) loyalty (5) futility

27. SILHOUETTE (1) cloth (2) garment (3) shadow
(4) streak (5) price

28. MENISCUS (1) bottom (2) crescent (3) weight
(4) size (5) color

29. ISOTROPIC (1) changed (2) identical (3) transferred
(4) opposite (5) isolated

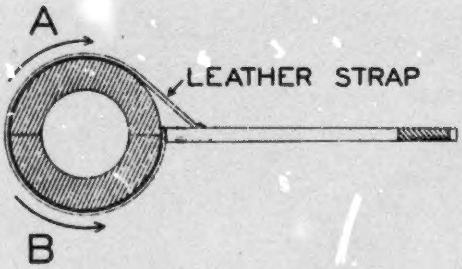
30. AMELIORATE (1) assimilate (2) improve (3) contaminate
(4) abuse (5) imperil

31. CONDUIT (1) easy (2) behavior (3) channel
(4) puzzle (5) concealed

PART III: Mechanical Comprehension

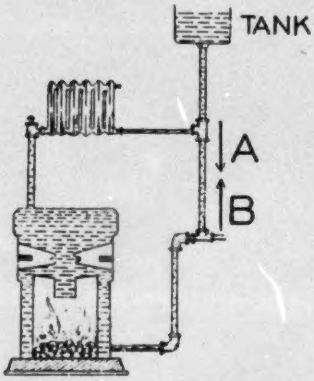
In the following pages are some pictures and questions. Read each question carefully, look at the picture and fill in the space one or two on the answer card. A in the picture will be choice one on the IBM card and B will be choice two.

1.


A
LEATHER STRAP
B

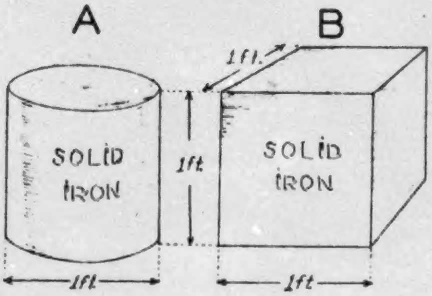
This wrench can be used to turn the pipe in direction:

2.



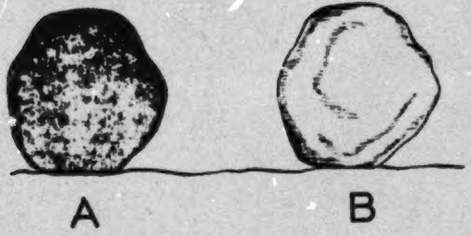
In which direction does the water in the right hand pipe go?

3.


A
B
1ft.
SOLID IRON
1ft
SOLID IRON
1ft
1ft

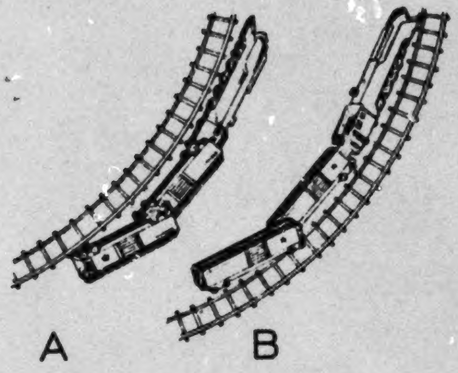
Which weighs more?

4.



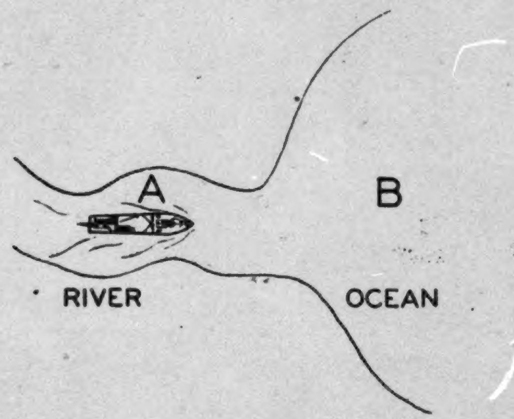
Which rock will get hotter in the sun?

5.



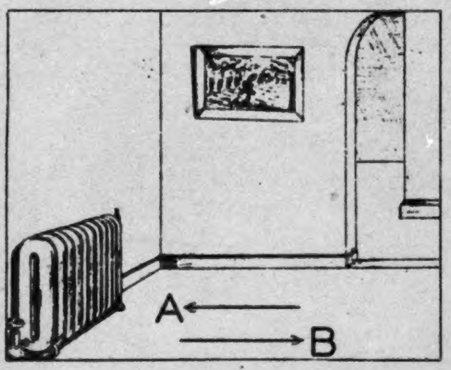
Which of these is the more likely picture of a train wreck?

6.



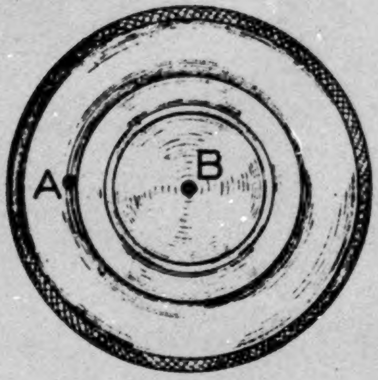
At which point will the boat be lower in the water?

7.



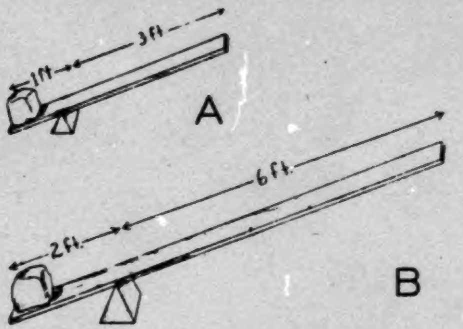
Which arrow shows the way the air will move along the floor when the radiator is turned on?

8.



Which spot on the wheel travels faster?

9.


1ft
3ft
A
2ft
6ft
B

With which arrangement can a man lift the heavier weight?

APPENDIX I

ATTITUDE INVENTORY

ATTITUDE INVENTORY

A computer pencil* should be used. Please bubble in your class sequence and student number on card. Turn the card over and bubble test section "1" at the top of the card.

In the following questions, we want to find out how you describe different things. There are no "right" or "wrong" answers, and no part of this test will in any way become part of your course or college record or affect your grades. Please answer to the best of your ability how you feel about each thing listed as a heading. For example, under a heading CHEMISTRY, you might find a pair of words separated by a scale looking like this: "EASY 1 2 3 4 5 HARD". You are to bubble in how you fee that word pair describes the heading CHEMISTRY. If you feel that CHEMISTRY is very closely connected with EASY, bubble in #1. If you feel that CHEMISTRY is only somewhat connected with EASY, bubble in #2. If you feel that CHEMISTRY is equally connected with EASY and HARD, or not connected with either, bubble in #3. If you feel that CHEMISTRY is somewhat or very closely connected with HARS, you would bubble #4 or #5 similarly. We are interested in your first impressions, so work rapidly and do not go back and change any marks. Be sure to check every scale, bubbling it only once.

DOING LABORATORY EXPERIMENTS

1.	IMPORTANT	1	2	3	4	5	UNIMPORTANT
2.	GLOOMY	1	2	3	4	5	JOYFUL
3.	SAFE	1	2	3	4	5	DANGEROUS
4.	INTERESTING	1	2	3	4	5	DULL
5.	USELESS	1	2	3	4	5	USEFUL
6.	VALUABLE	1	2	3	4	5	WORTHLESS
7.	BORING	1	2	3	4	5	FUN
8.	TIRESOME	1	2	3	4	5	EXCITING
9.	THREATENING	1	2	3	4	5	COMFORTING
10.	SIMPLE	1	2	3	4	5	DIFFICULT
11.	HAPPY	1	2	3	4	5	SAD
12.	MONOTONOUS	1	2	3	4	5	STIMULATING
13.	EFFORTLESS	1	2	3	4	5	DEMANDING
14.	RISKY	1	2	3	4	5	SECURE
15.	HARD	1	2	3	4	5	EASY

---

* A special scoring pencil used to "bubble" answer cards for machine scoring.

ATTITUDE INVENTORY (cont'd)

On the following questions, please answer on the scale:

STRONGLY AGREE 1 2 3 4 5 STRONGLY DISAGREE

16. Anything we need to know can be found out through science.

17. Scientific explanations can be made only by scientists.

18. Most people are not able to understand the work of science.

19. Scientists cannot always find the answers to their questions.

20. Scientific work would be too hard for me.

21. Some questions cannot be answered by science.

22. Rapid progress in science requires public support.

23. The value in science lies in its theoretical products.

24. Ideas are one of the more important products of science.

25. An important purpose of science is to help man to live longer.

26. Scientific laws cannot be changed.

27. Science is devoted to describing how things happen.

28. Scientists should not criticize each other's work.

29. I would like to work in a scientific field.

30. Scientific laws have been proven beyond all possible doubt.

APPENDIX J

COURSE EVALUATION

COURSE EVALUATION

USE AN IBM PENCIL FOR MARKING YOUR ANSWER CARD. DO NOT USE BALL POINT PEN OR RED PENCIL. ERASE ALL UNINTENDED MARKS.

KEY:
1. Strongly agree
2. Agree
3. Disagree
4. Strongly disagree

1. I learn more when other teaching methods are used.
2. My intellectual curiosity in the subject has been stimulated.
3. Overall, the course was good.
4. More courses should be taught this way.
5. The course held my interest.
6. I would have preferred another method of teaching in this course.
7. The course objectives were clear.
8. It was easy to remain attentive.
9. The instructor did not synthesize, integrate or summarize effectively.
10. Not much was gained by taking this course.
11. The instructor encouraged development of new viewpoints and appreciations.
12. The course material seemed relevant.
13. It was difficult to remain attentive.
14. Instructor did not review tests promptly and in such a way that students could understand their weaknesses.
15. Homework assignments were helpful in understanding the course.
16. There was not enough student participation for this type of course.
17. The content of the course was good.
18. The course increased my general knowledge.
19. The types of test questions used were good.
20. Held my attention throughout the course.
21. The demands of the students were not considered by the instructor.

110

22. Uninteresting course.

23. It was a very worthwhile course.

24. There was little class discussion,

25. The way in which this course was taught results in better student learning.

26. The course material was too difficult.

27. One of my poorest courses.

28. Material in the course was easy to follow.

29. More outside reading is necessary.

30. Course material was poorly organized.

31. Course was not very helpful.

32. It was quite interesting.

33. I think that the course was taught quite well.

34. I would prefer a different method of instruction.

35. The pace of the course was too slow.

36. At times I was confused.

37. Excellent course content.

38. The examinations were too difficult.

39. Generally, the course was well organized.

40. Ideas and concepts were developed too rapidly.

41. The content of the course was too elementary.

42. Some days I was not very interested in this course.

43. It was quite boring.

44. Another method of instruction should have been employed.

45. The course was quite useful.

46. I would take another course that was taught this way.

APPENDIX K

TEACHER EVALUATION

STUDENT EVALUATION OF THE TEACHING OF MIAMI-DADE COURSES

The purpose of this evaluation form is to furnish a basis for the continuous improvement of instruction. When these evaluation forms are used at the end of this term, they will not be looked at by the instructor until final grades have been filed. Your response is anonymous. DO NOT FILL IN YOUR NAME. After you have completed the 24 questions, hand in your answer card and questions. Mark your cnoice of answers on the card provided.

USE THE SCALE PROVIDED FOR THE FOLLOWING QUESTIONS:
(Do not write on this form.)

	1 Excellent	2	3 Fair	4	5 Very Poor
1. How do you rate him (her) as a teacher?	_____	_____	_____	_____	_____
2. How is his knowledge of his subject?	_____	_____	_____	_____	_____
3. How is the organization of his course?	_____	_____	_____	_____	_____
4. Are his explanations in class clear?	_____ Always	_____	_____ Usually	_____	_____ Seldom
5. How are his assignments?	_____ Clear	_____	_____ Usually Clear	_____	_____ Confusing
6. How enthusiastic is he in class?	_____ Very	_____	_____ Usually	_____	_____ Lacks enthusiasm
7. How is his ability to express his thoughts?	_____ Excellent	_____	_____ Usually has no difficulty	_____	_____ Has a great deal of difficulty
8. How is his sense of stressing important matters?	_____	_____	_____ Fair	_____	_____ Very poor
9. How is his ability to stick to the subject?	_____ Always sticks	_____	_____ Rarely	_____	_____ Gets completely off subject
10. Is opportunity given for students to participate in class?	_____ Often	_____	_____ Occasionally	_____	_____ Rarely

	1	2	3	4	5
11. How is his ability to inspire pupils?	_____ Excellent	_____	_____ Fair	_____	_____ Very poor
12. How much does he encourage the student to think for himself?	_____ A great deal	_____	_____ Some	_____	_____ Not at all
13. How are his tests as to coverage of material?	_____ Very reasonable	_____	_____ Usually Reasonable	_____	_____ Unreasonable
14. How is his grading as to fairness?	_____ Very fair	_____	_____ Usually fair	_____	_____ Very unfair
15. What is his attitude toward difference of opinions on controversial questions?	_____ Very Tolerant	_____	_____ Fairly tolerant	_____	_____ Very intolerant
16. How is his attitude as an instructor toward students?	_____ Very understanding and patient	_____	_____ Usually patient and understanding	_____	_____ Impatient and indifferent
17. How is his sense of humor?	_____ Exceptionally good	_____	_____ Vair	_____	_____ Very little
18. How often have you seen cheating in his class?	_____ Never	_____	_____ Sometimes	_____	_____ Very often
19. How is his personal appearance?	_____ Very neat	_____	_____ Usually neat	_____	_____ Very careless
20. How are his classroom manners?	_____ Very courteous	_____	_____ Usually courteous	_____	_____ Very discourteous
21. How is his speech?	_____ Easily understood and pleasant	_____	_____ Sometimes inaudible and indistinct	_____	_____ Very difficult to listen to
22. How about his mannerisms?	_____ Usually attractive classroom manners	_____	_____ Moderately free from distracting mannerism	_____	_____ Frequent annoying mannerisms

	1	2	3	4	5
23. Overall rating of courses	An outstanding course		A reasonably good course		A very poor course
24. If given the opportunity I would take another course with this instructor.	Yes		Maybe		No